The Engineer

LONDON, FRIDAY, NOVEMBER 6, 1942.

PUBLIC NOTICES

IGHTON TECHNICAL COLLEGE

Principal: W. MANSERGH VARLEY, M.A., D.Sc., Ph.D.

LECTURESHIP IN MECHANICAL ENGINEERING

Applications are Invited for the above APPOINTMENT, vacant owing to the promotion of the Senior Lecturer to Headship of Department. The Lecturer will be required to Take Charge of all Final Degree Work in Thermodynamics (Parts I and II), Hydraulics (Part I), and, if possible, Materials (Part II). Salary, Burnham Scale, with full allowances for research, industrial, and teaching experience, for high academic qualifications, and for special work of an advanced character, and applying the authorised war bonus, so that a highly qualified man of 28 to 30 years of age might commence at a salary of from £420-£450, correspondingly more for longer experience. Duties to commence 1st January or as soon thereafter as possible.

Form of application to be obtained from the undersigned, and returned to him not later than Friday, 20th November, 1942.

F. HERBERT TOYNE, B.A.,
Education Officer.

54, Old Steine,
Brighton. 8967

CITY OF SALISBURY, SOUTHERN RHODESIA

COAL-HANDLING PLANT

Tenders are Invited for the SUPPLY, DELIVERY, and ERECTION of the COAL-HANDLING PLANT at the Power Station now under construction at Salisbury, in accordance with the City Council's Specification.

One copy of the specification may be obtained from the Consulting Engineers, Messrs. Merz and McLellan, 32, Victoria Street, London, S.W.1, on and after Monday, 9th November, 1942, on payment to them of a fee of £5 5s.

Additional copies of the specification may be obtained from the Consulting Engineers in London on payment of £2 2s. for each such additional copy.

Sums paid on any number of copies up to four will be refunded on receipt of a bona-fide Tender.

Tenderers are requested to note that a Certificate of Essentiality for the above plant and equipment is assured by the Southern Rhodesia Ministry for Co-ordination of Supplies.

Sealed Tenders, with all relative documents endorsed to indicate the item to which they relate, must be delivered in triplicate as follows:

(1) Two copies of the original Tender and documents to the OFFICIAL SECRETARY, Office of the High Commissioner for Southern Rhodesia, Rhodesia House, 429, Strand, London, W.C.2, not later than Monday, December 7th, 1942.

(2) One duplicate Tender and documents to Messrs. MERZ and McLELLAN, 32, Victoria Street, London, S.W.1, not later than 24 hours after deposit of the original Tenders and documents with the High Commissioner.

The Council do not bind themselves to accept the lowest or any Tender. 8948

CITY OF LEICESTER

APPOINTMENT OF DEPUTY WATER ENGINEER AND MANAGER

Applications are Invited for the POST of DEPUTY WATER ENGINEER and MANAGER of the City of Leicester Water Undertaking. Commencing salary, £600 per annum, plus cost-of-living bonus (at present £24 per annum), rising (subject to satisfactory service) by annual increments of £50 to £750 per annum.

Applications, on a form which may be obtained from the undersigned, should be returned in envelopes, endorsed "Deputy Water Engineer," together with copies of not more than three recent testimonials, so as to be received not later than Friday, the 27th November, 1942.

The appointment will be subject to the provisions of the Local Government Superannuation Act, and the successful candidate will be required to pass a medical examination.

Canvassing any member of the Council or any Committee thereof, either directly or indirectly, will disqualify.

L. McEVOY,
Town Clerk.

Town Hall,
Leicester,
3rd November, 1942. 8964

TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

The Engineer

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PUBLIC NOTICES

THE INSTITUTION OF CHEMICAL ENGINEERS

EXAMINATION, 1943

Application Forms (Returnable 21st December, 1942) and particulars of the ASSOCIATE MEMBERSHIP EXAMINATION for 1943, together with the MEMORANDUM on "The Training of a Chemical Engineer" may be obtained from the HON. REGISTRAR, Institution of Chemical Engineers, 56, Victoria Street, Westminster, London, S.W.1. 8949

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

IMPORTANT

Advertisers in Situations Open Column should make themselves acquainted with the terms of

STATUTORY RULES & ORDERS 1941 No. 2069

RESTRICTION ON ENGAGEMENT ORDER

CIVIL ENGINEER (TEMPORARY) REQUIRED on Land Drainage Schemes in Cheshire. The salary offered is £300 per annum, plus £33 10s. per annum war bonus, and, subject to satisfactory service, the appointment will be for a period of three years. Applicants should possess a motor-car, for which travelling allowance will be made.—Apply at once, giving full particulars, to the ENGINEER, Cheshire Rivers Catchment Board, The Castle, Chester. 8973 A

PROGRESS MANAGER REQUIRED for large General Engineering Works in the North, engaged on a wide variety of work.—Address, stating age, experience and salary required, 8893, The Engineer Office. 8893 A

THE Post You are Seeking May Not be Advertised in this Column, but do not lose the Opportunity of Bringing your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for the cost of Four Lines, 6s.; 1s. 6d. for each Additional Line. There is no better way of covering so large a field for such a small charge.

THE SOMERSET RIVERS CATCHMENT BOARD have a VACANCY for an ASSISTANT at a salary of £300-25-£350.—Apply to the ENGINEER, West Quay, Bridgwater. 8966 A

GENERAL FOREMAN WANTED to Supervise the Manufacture of Hydraulically Pressed Concrete Slabs; capable of maintenance and repairs essential. State experience and wages required.—THE ALEXANDRA STONE CO., Ltd., Oxford Avenue, Trading Estate, Slough. 8961 A

SITUATIONS WANTED

A.M.I. MECH. E., Just Released, DESIRES RE-ENGAGEMENT in responsible position. Technical, workshop, and D.O. training. Last position chief engineer in large works.—Address, P4470, The Engineer Office. P4477 B

CHASER, Aged 43, REQUIRES, Preferably North-Eastern, OUTSIDE APPOINTMENT. Wide experience material control and progress.—Address, 8956, The Engineer Office. 8956 B

SITUATIONS WANTED

CHIEF ENGINEER (41), Wide Experience steel works, coke ovens, by-products, chemical plants, &c., DESIRES CHANGE to post carrying four-figure salary, giving scope for high administrative and organising abilities.—Address, P4472, The Engineer Office. P4479 B

ENGINEER, Qualified Civil, Mechanical, Structural, and Building, works and university training, executive experience, age 46, SOON AVAILABLE for RESPONSIBLE POST with substantial salary. Would plan post-war development or peace products.—Write, F218, Deacons, St. Mary Axe, E.C.3. 8962 B

IF the Man You Are Seeking is Not Amongst those Advertising in this Column, a Small Announcement in the "Situations Open" Column will Quickly and Economically Produce the Right Selection of Applicants, at the same time Eliminating Waste of Effort, Waste of Time, and Waste of Opportunity. The charge is Four Lines or under, 6s.; each Additional Line, 1s. 6d. Box Numbers, 1s. extra, which includes despatch of all replies.

MANAGER of Marine Engine Works, with boiler-shop and fitting-out quay, DESIRES EXECUTIVE POST, with prospects.—Address, 8970, The Engineer Office. 8970 B

MECH. ENGINEER, Age 29, Engineering degree, good practical, design and sales experience and some electrical knowledge, REQUIRES PERMANENT POST with prospects.—Address, P4469, The Engineer Office. P4469 B

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WORKS ENGINEER DESIRES TO CHANGE to a factory where the team spirit is foremost; capable of controlling large maintenance staff and D.O., also design and construction of factory lay-out, buildings, steam, hydraulic, exhaust plants, &c.—Address, P4482, The Engineer Office. P4482 B

WORKS or PRODUCTION MANAGER, thoroughly experienced all branches, good disciplinarian; can really get production.—Address, P4478, The Engineer Office. P4478 B

MISCELLANEOUS

BOUND VOLUMES or COPIES of "THE ENGINEER," January to June, 1932, and January to June, 1937, WANTED.—Address, F. M. P. (or telephone Central 6565), The Engineer Office. 8873 I

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CLASSIFIED ADVERTISEMENTS CLOSE FOR

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The Engineer

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The Charges for Classified Advertisements are 1/6 per line up to one inch—minimum charge, 6/-; those occupying one inch or more at the rate of 18/- per inch. Box numbers, 1/- extra, except in the case of advertisements under "Situations Wanted." Orders MUST be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher; all other letters are to be addressed to the Editor of THE ENGINEER.

Postal Address,
28, Essex Street, Strand, London, W.C.2.

Teleg. Address,
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Tel., Central 6565 (10 lines).

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MACHINERY, &c., WANTED

WANTED, CIRCULAR COLD SAW (Metal Sawing), capacity 24in. diameter.—Details and price to J. F., Staffa Works, Staffa Road, Leyton, E.10. 8968 F

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PATENTS

THE PROPRIETOR of the Following BRITISH PATENTS DESIRES to NEGOTIATE with interested parties with a view toward EXPLOITING these inventions, on reasonable terms, in Great Britain:—
No. 507,265, "Improvements in or relating to Milling Cutters."
No. 316,816, "Improvements in or relating to Rotary Cutting Tools for Metal and Wood-working Machines."
No. 303,496, "Improvements in Cutters for Metal Cutting and like Machine Tools."
No. 396,491, "Improvements in and relating to Metal Cutting Tools."
No. 398,916, "Improvements in and relating to Lathe and like Cutting Tools."
For particulars kindly address ALBERT F. NATHAN, Patent Counsel, Professional Building, Plainfield, N.J., U.S.A. 8951 H

THE PROPRIETORS of BRITISH PATENT No. 513,963 are PREPARED to SELL the PATENT or to LICENSE British Manufacturers to work thereunder. It relates to Electro-deposition of Nickel.—Address, BOULT, WADE and TENNANT, 112, Hatton Garden, London, E.C.1. 8960 H

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Especially in view of Air Raid and Working Conditions, study at home with the T.I.G.B. in order to achieve the best progress and results. Write to-day for "The Engineer's Guide to Success"—FREE—containing the world's choice of Engineering Courses—over 200—covering all branches and recognised qualifications. Mention branch, post of qualifications that interests you. The T.I.G.B. guarantees training until successful.

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76, TEMPLE BAR HOUSE, LONDON, E.C.4.

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For continuation of Small Advertisements see page 64.

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A Seven-Day Journal

The Canadian-Alaskan Highway

In our issue of October 2nd we recorded the advanced state of the work of constructing the 1600-mile-long Canadian-Alaskan Highway, known as the Alcan Highway, which has been built by United States Army Engineers to the order of the Canadian and United States Governments. Work on the road was begun in March last, and on Thursday of last week, October 29th, it was officially announced by Mr. Henry L. Stimson, the United States Secretary of War, that the whole of the new highway had been opened to traffic. The formal opening, it is announced, will take place on Sunday, November 15th, at a point on the Canadian and Alaskan border. The road runs from Dawson Creek in British Columbia to Fairbanks in Alaska. Its completion in a period of a little more than six months marks the successful end of an important feat of civil engineering work. Several thousand United States soldiers and some 2000 civilian workers pushed the road forward at the average rate of 8 miles a day, using as their building materials stone and rock found on the spot. The cost of the Highway has been about £7,500,000. Lorries began to run over the road last week, and about 1000 of them will continue to run all the winter. Plans are being made for them to carry strategic materials to the south when making the return trip. It is pointed out that the present terminal point on the Highway, Fairbanks, is about 2000 miles from Japan by way of the Aleutian Islands, and it connects by way of the Yukon with Nome, 95 miles from Siberia, across the Behring Straits, which are only 56 miles wide at their narrowest point.

U.S. Aeronautical Experts in Britain

It is announced by the Ministry of Aircraft Production that the important mission of United States aeronautical experts in this country, which has made an extensive tour of British aircraft factories, has now completed its work. The mission was headed by Mr. T. P. Wright, the Director of Aircraft Production of the United States War Production Board. Other members were :—Mr. W. K. Ebel, the vice-president and chief engineer of the Glenn L. Martin Company ; Mr. A. G. Herieshoff, the Chrysler Company ; Mr. P. G. Johnson, president of the Boeing Aircraft Corporation ; Mr. I. M. Laddon, vice-president and chief engineer of the Consolidated Aircraft Corporation ; Mr. Charles Marcus, of the Bendix Corporation ; Mr. S. A. Stewart, of Hamilton Standard Propellers ; Mr. J. Carlton Ward, of Fairchild Engine and Airplane Corporation ; and Mr. G. E. Welty, of the Aluminum Company of America. In a broadcast talk on Sunday, November 1st, Mr. T. P. Wright said that the exchange of trips had, he felt, been important both from the standpoint of view of practical knowledge gained by seeing and discussing production methods, and because of the psychological benefits of the contacts made. The American contributions had been more in the nature of mass-production technique, involving the use of conveyor systems and specialised single-purpose tools. The production efforts of Britain and America were, he felt, complementary in character, each nation supplementing the work of the other so as to make an effective joint programme. The deputation, Mr. Wright concluded, had been greatly and most favourably impressed by much they saw in British aircraft factories.

Government Long-Distance Road Traffic Scheme

It was announced by the Ministry of War Transport on Monday, November 2nd, that in order to meet the difficult situation in the road haulage industry, arising from the measures which are necessary to conserve rubber and motor fuel and in order to make the best possible use of road haulage vehicles, the Government has decided, solely as a wartime measure, to bring the longer-distance road haulage traffic under control. The control may be extended later to include shorter-distance traffic and vehicles, but during the initial stages it is primarily intended to cover goods conveyed for distances of 60 miles and upwards. It is estimated that some 25,000 vehicles now engaged in this long-distance traffic will be directly controlled by the Government as the scheme is brought into operation. The traffic now handled under the existing road haulage scheme will be dealt with by the enlarged organisation, which will unify and absorb the functions of the Hauliers' National Traffic Pool and its local branches. Under this enlarged organisation of the Ministry of War Transport, there will be twelve divisions, coinciding with the Civil Defence Regions, and each division will be subdivided into areas. The Divisional and Area Haulage Officers will be mainly drawn from the haulage industry, but will not be actively associated with the running of any private road haulage business while they hold office. Vehicles will be grouped into about 450 units, each centred on a firm with the necessary facilities. There will be a Controller for each unit, who will normally be a member of the staff of that firm. Owners of the controlled vehicles will retain their business identities, and will continue to maintain their own vehicles and employ their own drivers. Short-distance traffic carried under the existing road haulage scheme will continue to be dealt with by the Area Officers. Close contact will be maintained with the Regional Transport Commissioners, who will supervise the issue of fuel to the units.

British Refrigerated Tonnage

It has been known for some time past that part of our merchant shipbuilding programme includes refrigerated tonnage specially designed to ship food cargoes to Great Britain. To assist the rapid production of additional refrigerated tonnage, it was decided in May last to equip some of our standard 10,000-ton cargo vessels with refrigerating plant, so as to enable these ships to carry perishable food. By taking two or three cargo holds of a standard cargo vessel and fitting the necessary insulation along with appropriate steam-driven refrigerating plant, it was found possible to obtain a refrigerated capacity of from 250,000 to 300,000 cubic feet. The first ship to be so equipped has, we are informed, now completed its first voyage most successfully with a meat cargo, and has already started on its second voyage. Meanwhile, other cargo vessels have been similarly equipped and will shortly enter service. This new development bears witness to the flexibility of our merchant shipbuilding programme. It may also be stated that during the recent summer months twice as much refrigerated work was in progress in British shipyards, compared with the highest amount of such work completed in a similar period before the war.

Transport in Time of War

In an address given on Tuesday, November 3rd, to the Institute of Transport, Lord Leathers, the Minister of War Transport, dealt with problems relating to wartime transport. With regard to passenger transport, he said that all our ocean-going passenger ships, as well as many similar ships belonging to the Allies, were being used for moving British and Allied Forces overseas. At home on the railways priority was being rightly given to movements of workers and troops, and improvements had been effected where staggered hours were worked. In order to give priority to workers, it had been necessary to run about 1000 extra trains for them. The railways, Lord Leathers said, were now carrying 34 per cent. more workers than before the war, while some bus undertakings were carrying 60 to 100 per cent. more passengers, and many companies 30 to 50 per cent. more. The shipping side of the problem had been well handled, both in this country and America, and the War Shipping Administrations in Washington and London had done excellent work. After three years of murderous attacks on our ships, we were still well fed, and our war factories were producing an ever-increasing output from raw materials, many of which had to be brought from overseas. That was no mean achievement. The Minister paid special tribute to the work of the coastal ships. Those ships had lightened the problems of distribution, and were making altogether some 25,000 voyages a year round our coasts. Such an arrangement had involved already more than 1000 coastal convoys, and meant non-stop work for all concerned. Dealing with goods traffic, Lord Leathers said that we were now planning to run up to 200 more freight trains every day than we did last winter. That work would be greatly helped by the additional railway tracks, sidings, and marshalling yards which had been completed. Lord Leathers closed his address with a reference to the new road haulage scheme outlined in one of our other Journal notes, and paid a heart-felt tribute to the work of men and women working in our various transport services.

Warehouse and Factory Accommodation

Under a new Order issued by the Board of Trade, licences must now be obtained before any use may be made of any factory or warehouse accommodation. It will be recalled that under the Location of Industry (Restriction) Order of 1941 all premises with areas of 3000 square feet or more were brought under the Order and made subject to licence regulations. Under the new Order, which came into force on October 12th, all premises, the area of which is less than 3000 square feet, are now included under the regulations. Thus all factory and warehouse, and also storage, accommodation now comes within the restriction Order, except that which was in operation up to and including October 11th, 1942. The new Order prohibits a change of occupier, except by licence, even where there is no change in the use of the premises concerned. Premises which are used for the storage of motor vehicles come within the scope of the restrictions, but retail shop accommodation is not involved. Retail premises, it may be noted, are still subject to the Location of Retail Businesses Order, and licences issued under the 1941 Order remain valid. No licence is required in the cases of premises which are used for periods of less than twenty-eight days. Applications for licences, it is stated, must be made to the appropriate Regional Controller of Factory and Storage Premises.

Austerity Locomotives

The announcement is made that the War Office has placed an order for a special form of simplified goods locomotive, designed for the hauling of munitions and troop trains. The first of these so-called "austerity" locomotives will probably be seen on our railways by the end of this year. They will be painted a khaki colour and will be marked on the tender by "W.D." and a number. They will be of standard gauge, specially designed to run also on European railways, and they are to be fitted with either vacuum or Westinghouse brake equipment, or both, with an additional steam brake on the engine and tender. The firebox is designed so that it can be quickly adapted to burn either coal or oil fuel. The design adopted for these locomotives is stated to be simple, and saves many hundreds of man-hours in construction. A figure of 20 per cent. possible saving in the number of man-hours required per engine has been mentioned. Specially large tenders are to be used, so that the locomotives can work in districts where supplies of fuel and water may be far apart. They will be powered to draw a load of between 500 and 700 tons at a maximum speed of between 30 and 40 m.p.h. The locomotive-building firms of Great Britain and the United States are combining their resources in order to meet the demand for this new type of engine, but it is understood that the American firms will construct engines to their own designs.

Historic Accidents and Disasters

No. XVI*

Colliery Disasters—Part II

ALLUSION was made in introducing the subject of colliery disasters to the two greatest colliery explosions which have occurred in the annals of coal-mining, namely, at Courrières in the Pas de Calais, France, and at Senghennyd in South Wales, Great Britain.

Courrieres Colliery Explosion

With regard to the first-named appalling calamity, passing reference is made to it because in point of death-roll it is the greatest coal-mining disaster on record. On account of its magnitude, the Home Secretary directed Mr. H. H. Conynghame, C.B., Assistant Permanent Under-Secretary at the Home Office, and Mr. W. H. Atkinson, one of H.M. Inspectors of Mines, to examine into its causes and to report thereon to him. To this report the inquiring reader is referred for further and more detailed particulars, as also to *La Catastrophe de Courrières*, by Monsieur Ch.-E. Heurteau, Ingénieur au Corps des Mines (Paris, 1907), and to an excellent paper contributed to the Institute of Mining Engineers by Messrs. W. N. Atkinson and A. M. Henshaw in 1906.

The seams at the Courrières Collieries numbered no less than forty-four, the aggregate thickness being 139ft. 9in. Of these, ten were affected by the explosion. The area of the concession held by the coal company, granted by the State, comprised 13,489 acres, worked from twelve shafts or pits.

This explosion in a mine, or rather group of interconnected mines, in which inflammable gas had rarely been detected and in which many open lights were in use, caused great consternation and gave rise to much wonderment as to its cause, was traced to a blown-out shot, and was attributed by the investigators to coal dust, the roadways and workings being to a large extent dry and dusty. The French General Council of Mines arrived at the following, among other, conclusions :—

"Considering that, as has been said, it has been impossible, in spite of the most persevering and attentive investigation, to establish the exact cause of the initial inflammation which determined the catastrophe of March 10th, 1906, it is beyond question that its extension appears to have been due, in consequence of various circumstances, to the propagation of the inflammation of dust throughout the whole extent of the workings of No. 2, No. 3, and Nos. 4–11 pits, over a length of about 3 kilms. (3280 yards), and here and there over a width of 1½ kiloms. (1640 yards)."

Senghennyd Colliery Explosion

We come now to the great explosion at Senghennyd, which occurred at about 8.10 a.m. on October 14th, 1913, the greatest catastrophe in the history of British coal-mining.

The Chief Inspector of Mines (Mr. Richard Redmayne, C.B.) arriving at the colliery late in the afternoon of that day, after an examination of the working plans and discussions with the management and others, thereafter proceeded underground, and was in attendance at the colliery during the four succeeding days. He again visited the colliery on October 17th, when he made a further underground inspection, as also on December 2nd and 13th, 1913, when the west side of the mine having been sufficiently recovered, he was able to travel over a great part of that side of the mine (see plan, page 373).

Having been appointed by the Home Secretary to hold an inquiry into the cause of the disaster, he opened the proceedings at Cardiff on January 2nd, 1914, sitting with Mr. Evan Williams (Chairman of the South Wales and Monmouthshire Coalowners' Association, and now Sir Evan Williams, Bart., and Chairman of the Mining Association of Great Britain) and the late Mr. Robert Smillie (President of the Miners' Federation of Great Britain) as assessors. The inquiry occupied sixteen days, thirteen of which were absorbed in hearing evidence, during which 21,837 questions in all were put to witnesses !

Three separate reports were issued.

The Senghennyd Colliery, sometimes called the Universal Colliery, is situated at the head of the Aber Valley in Glamorganshire, about 12 miles as the crow flies N.N.W. of Cardiff. It could not be included within the category of "safe" or "non-gassy" collieries ; nor was it the first occasion on which an explosion had been experienced thereat, for on May 21st, 1901, eighty-one persons had lost their lives from such a calamity, as to the cause of which no definite conclusions were forthcoming.

It was a large colliery, with a daily output of about 1800 tons of coal. The workings were divided into two main divisions, viz., the west side and the east side.

In order to follow the course of reasoning by which the Chief Inspector determined the site and probable cause of this great disaster, the reader must have recourse to the plan of the part of the mine chiefly affected by the explosion, that is, of the west side, which is reproduced in the plan.

The seam worked on the West Side was the Four Feet. On the East Side were worked the Four Feet, the Universal, and the Nine Feet seams, these seams being inter-connected on that side, and the coal wrought in each seam brought to one level by means of cross-measure drifts.

We need, however, only direct our attention to the West Side, as the explosion was confined to that side, passing only a few yards into the East Side.

The West Side comprised six "districts," namely, the West York, Pretoria, Mafeking, Kimberley, Ladysmith, and Bottanic districts, which, it will be observed, all branched away from the "main intake" or arterial roadway known as the Main West Level. These districts were, for the purpose of the statutory daily inspections by the firemen (or deputies ; sub-officials on whom this duty devolves), divided into sub-districts.

Shot-firing as a possible cause of the initiation of the explosion was at once ruled out, for no explosives were used at the mine except in those cases where the roof stone (taken down to make the height necessary to permit of the passage of men and the ponies hauling the tubs to the main or mechanical haulage) was particularly hard, and in driving cross-measure drifts—the latter a rare occasion. In any event, no blasting was being carried out at the colliery on the day of the explosion, and no shots had been fired thereat since October 12th—two days before the explosion.

It is important to note the following facts :

(1) *Mechanical Haulage.*—The mechanical haulage of the coal wrought in Mafeking, West York, Bottanic, and part of the Pretoria districts was carried out in the return airways of those districts—usually at collieries the intake airways constitute the haulage roads. These roads therefore would be dusty (the mine was a warm one and mainly a dry one). The main haulage roads of the Kimberley and Ladysmith districts were the intake airways. All the main haulage roads had been traversed by waves of explosive violence.

(2) Now, mines which were opened—as this one was—before the passing of the Coal Mines Act of 1911, are exempt from the requirement to the effect that where the air current in the main return airway is found normally to contain more than ½ per cent. of inflammable gas, that airway shall not be used for the haulage of coal. These roads, too, would be certain to contain much coal dust, for the coal trams were so constructed—as was characteristic of coal trams in use at South Wales collieries generally at that time—as to allow of the escape of small coal and dust in their passage along the roadways. Under the Coal Mines Act, 1911, no trams for the conveyance of coal can be introduced into a mine after the date of the passing of the Act unless it is so constructed and maintained as to prevent as far as practicable coal dust escaping through the sides, end, or floor of the tram ; and, after a period of five years from December 16th, 1911 (the date of the passing of the Bill), all trams, whether old or new, had to conform to this requirement. This injunction was in course of being complied with when the explosion occurred.

(3) *The Presence of Inflammable Gas.*—As has already been pointed out, the mine was, in respect of the volume of "gas" generated therein, typical of the more "fiery" mines in the steam coal area of the South Wales coalfield ; but with ventilating currents in the aggregate amounting to 205,130 cubic feet per minute, as measured in the intake, the percentage of methane in the air did not amount to more than from 0·40 to 0·59 per cent. in the main return airway. But that the mine was subject on rare occasions to sudden outbursts of inflammable gas was proved by the fact that in October, 1910, when a large fall of roof took place in the Mafeking level in the neighbourhood of some faults (see plan), there was a large discharge of gas, which continued to be delivered for four days after the fall had been cleared away. So great was this discharge that the workmen had to be withdrawn from the mine.

(4) *Coal Dust.*—The coal screens being stationed about 80 yards from the top of the downcast shaft, little dust would be carried therefrom down the shaft and into the mine by the intake air ; but dust would be blown from the heaped-up coal in the trams advancing against the air current, where the haulage roads were in the intake, and even when moving with the air current, where the haulage roads were in the return airways, as well as the open character of the trams, already alluded to, would make for the formation and deposition of dust along these roadways. Every afternoon and night a few men were engaged in shovelling up dust from the floor of the roadways, but the whole length of these roads was not cleared every twenty-four hours, and the roof and side were not cleared at all. In fact, to put it plainly, the requirements of the Coal Mines Act in this respect were not being fully observed.

It will be realised that the rendering of the coal dust innocuous by its adulteration with inert (stone) dust, now systematically operative at all coal mines which are not damp throughout, was not at that time enforced.

* No. XV appeared October 30th.

Water pipes were laid along the main haulage roads and were in use for watering the floor, but the roof and sides were not watered. It was impracticable to do so, as the application of water would have disturbed them to the extent of bringing on a "squeeze" and cause the roadways to collapse—such is the character of the strata in this part of the South Wales coalfield. Water sprinklers to damp the coal-loaded trams were also in use, but were so situated that a great deal of dust would be blown from the trams on their outward journeys to the shaft before reaching the sprinklers.

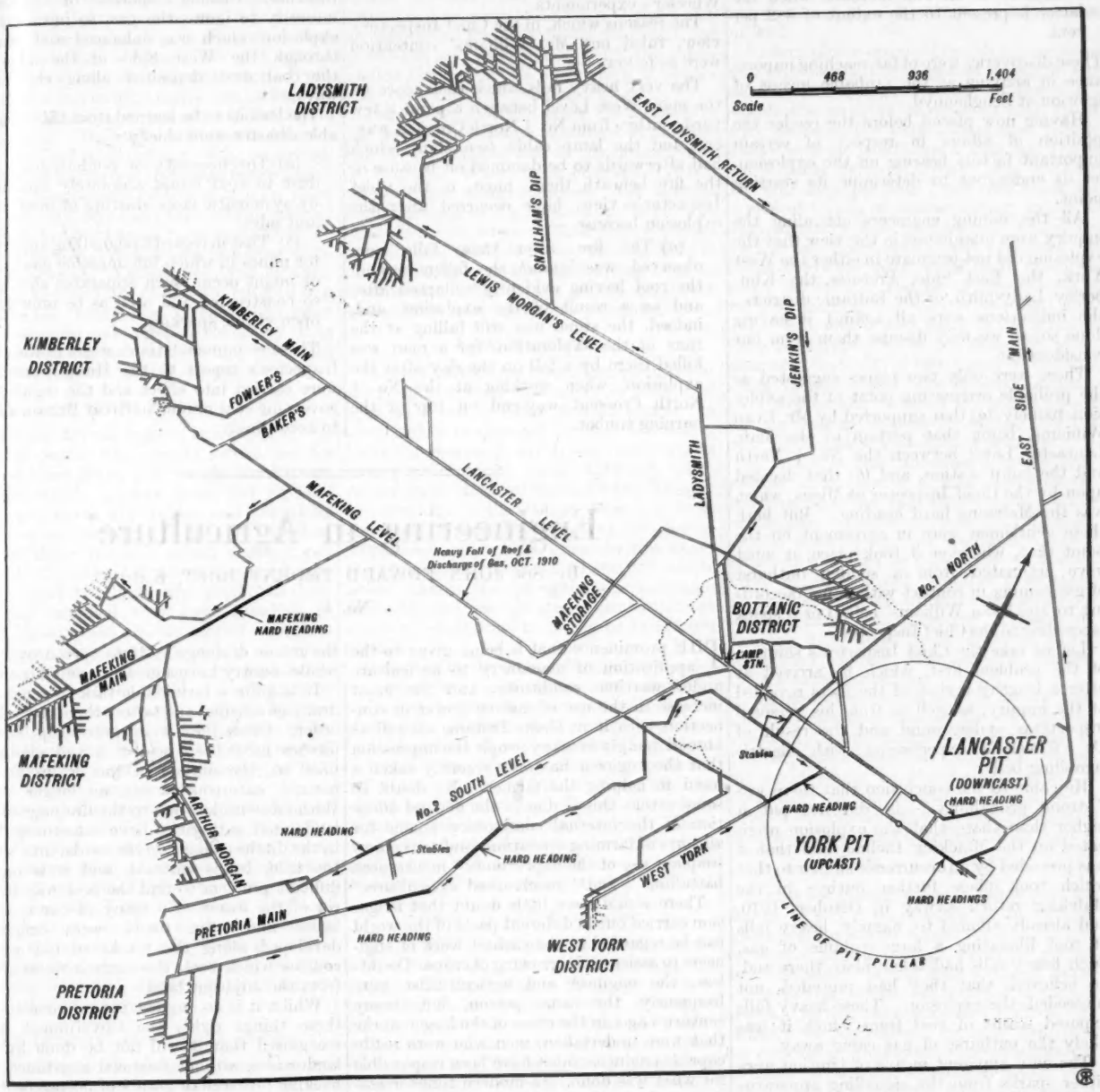
(5) *Safety Lamps.*—The type of safety lamp in use at the mine was that known as the "Cambrian," and was provided with a lead rivet locking device. The lamps were lighted, locked, and issued to the workmen and officials at the surface and were examined underground at places termed "locking stations." If anyone lost his light when at work, he had to come out to the locking station of the district he was working in in order to have it relit by an authorised person known as a "lamp locker."

(6) *Signalling Arrangements.*—The main haulages were effected by wire ropes actuated by stationary compressed air hauling engines. In some parts, however, notably in the instance of the inclined haulage road in the Mafeking district, the haulage was worked by gravity; that is to say, it constituted a self-acting incline.

The system of signalling in use at the mine calls for especial notice, as being the most probable cause of the ignition of the fire-damp which initiated the explosion. It consisted of (*a*) electric bells of the trembler pattern (which, though protected by cast iron covers, were not gas-tight), a battery of from six to nine dry cells of the "Dania" pattern, giving, when new, about 1·5 volt per cell; and (*b*) two bare wires supported on insulators, the wires being 12in. to 18in. apart and on the same side of the roadway.

Three electrical experts who gave evidence at the inquiry agreed in putting the pressure of the signalling circuits at or below 9 volts. The late Mr. Charles Sparks had had the pressures of the battery at the foot of the "hard heading" (see plan) measured two months after the explosion—after the individual cells had been got together—when the pressure obtained on open circuit was 10·34 volts. Mr. Shielbach, another of the three electrical experts, gave the pressure of the battery at the top of the "hard heading," taken two months after the explosion, as 11·45 volts. Both voltages dropped rapidly on closed circuit to 6·9 and 3·79 volts respectively after a short time, indicating that, though the individual cells had recovered their pressure somewhat, they were, in fact, approaching exhaustion—cells do recover if left to themselves unused.

The general effect of the evidence of the electrical experts was to show that sparks produced by the signalling apparatus—either at the bells themselves or caused at the point of bringing the two wires together—which was the method of signalling commonly adopted by the haulage signallers—were of insufficient intensity to ignite fire-damp. The Chief Inspector, however, was not satisfied on the point, and at his request had experiments carried out by the late Dr. Wheeler, the results of which were forth-



"The Engineer"

THE SENGHENNYD COLLIERY IN 1913

coming after the termination of the hearing of evidence. These proved conclusively that :

(*a*) The amperage of the current, from the point of view of possibility of ignition of inflammable gas by a spark, is of more importance than the voltage.

(*b*) That with three Dania cells, giving a current (on closed circuit) of 0·45 ampere under a pressure (on open circuit) of 4·5 volts, it is possible to produce a spark by short circuiting the current in signal wires to give a signal which will explode a mixture of air and methane when the latter is present to the extent of 8·2 per cent.

These discoveries were of far-reaching importance in arriving at the probable means of ignition at Senghennyd.

Having now placed before the reader the position of affairs in respect of certain important factors bearing on the explosion, let us endeavour to determine its starting point.

All the mining engineers attending the inquiry were unanimous in the view that the explosion did not originate in either the West York, the East Side, Pretoria, the Kimberley, Ladysmith, or the Bottanic districts ; the indications were all against it having done so, so we may dismiss them from our consideration.

There were only two places suggested as the probable originating point of the explosion, namely, (*a*) that supported by Mr. Evan Williams, being that portion of the Main Lancaster Level between the No. 1 North and the lamp station, and (*b*) that decided upon by the Chief Inspector of Mines, which was the Mafeking hard heading. But both these gentlemen were in agreement on the point that, wherever it took place, it must have originated from a sudden outburst of gas coming in contact with flame (according to Mr. Evan Williams' belief) or a spark (according to the Chief Inspector).

Let us take the Chief Inspector's solution of the problem first, which he arrived at after a lengthy review of the facts revealed at the inquiry, as well as from his personal inspections underground and the result of Dr. Wheeler's experiments with electric signalling bells.

He came to the conclusion that there was "strong probability"—he did not put it higher than that—that the explosion originated on the Mafeking Incline, and that it was preceded by an occurrence similar to that which took place further outbye in the Mafeking return airway in October, 1910, and already alluded to, namely, heavy falls of roof liberating a large volume of gas. Such heavy falls had taken place there and, he believed, that they had preceded, not succeeded, the explosion. These heavy falls exposed seams of coal from which it was likely the outburst of gas came away.

The only apparent means of ignition were either sparks from the signalling apparatus or from rocks brought down by a fall of roof. It might, however, be asserted that other means might have been (*a*) the flame of an open or damaged safety lamp or (*b*) the striking of matches, but against these possibilities must be put the fact (*a*) that no lamp was found in the place. There were lamps lower down the hard heading, but there was no evidence whatever pointing to any of them having been the igniting means of the explosion ; and (*b*) as to matches being the possible cause, these are ruled out by the fact that a rigorous search of every person entering the mine and before going inbye was carried out daily.

As to the source of the inflammable gas, Mr. Evan Williams believed that it came from a large fall of roof on the Main Level, inside the No. 1 North, which fall took place before the explosion, and he disagreed with the Chief Inspector's reasons (given below) to the contrary. He was of the opinion that the explosion was caused by the presence of an open light in the lamp cabin (relocking station, where, in fact, an open lamp was found after the explosion). He eliminated the signalling apparatus from the list of possible causes, but in justice to him it must be stated that he was unaware at the time he wrote his report of the result of Dr. Wheeler's experiments.

The reasons which, in the Chief Inspector's view, ruled out Mr. Williams' contention were as follows :—

The very heavy falls which took place on the main West Level between a point a few yards outbye from No. 1 North Crosscut way-end and the lamp cabin (see plan), which had afterwards to be dammed off because of the fire beneath them, must, in the Chief Inspector's view, have occurred after the explosion because :—

(*a*) The fire, after these falls were observed, was *beneath* the fallen ground, the roof having evidently collapsed after and as a result of the explosion, and, indeed, the stone was still falling at the time of the exploration, for a man was killed there by a fall on the day after the explosion, when working at the No. 1 North Crosscut way-end on top of the burning timber.

(*b*) It is difficult, if not impossible, to account for the ignition of the timber below the fall on the supposition that the fall occurred first. In the later case, too, the fire would have spread inbye beyond the fall.

Mr. Smillie concurred with the Chief Inspector's conclusions regarding the point of origin and cause of the explosion, namely, an outburst of gas resulting from heavy falls of ground from some upper bands of coal, the fall, by bringing the bare signalling wires together, causing sparks of sufficient intensity to ignite the gas, so initiating an explosion which was enhanced and carried through the West Side of the mine by the coal dust deposited along the roadways.

The lessons to be learned from this lamentable disaster were chiefly :—

(*a*) The necessity of rendering all coal dust in coal mines absolutely innocuous by systematic stone-dusting of floor, roof, and sides.

(*b*) That in regard to signalling apparatus for mines in which inflammable gas occurs or might occur, such apparatus should be so constructed and used as to prevent all open visible sparking.

These recommendations, made in the Chief Inspector's report to the Home Secretary, were carried into effect and the regulations governing coal mining in Great Britain added to accordingly.

Engineering in Agriculture*

By Sir JOHN EDWARD THORNYCROFT, K.B.E.

No. I

THE prominence that is being given to the application of machinery to agriculture under wartime conditions, and the great increase in the use of motive power in connection with it in Great Britain, as well as abroad, has given many people the impression that the engineer has only recently taken a hand in helping the farmer. No doubt to some extent this is due to the general adoption of the internal combustion engine for all sorts of farming operations and to the now frequent use of the expressions "mechanised battalions" and "mechanised agriculture."

There would seem little doubt that irrigation carried out in different parts of the world can be regarded as the earliest work of engineers to assist in the growing of crops. Doubtless, the engineer and agriculturlist were frequently the same person, but many centuries ago, in the cases of the larger works that were undertaken, men who were really capable engineers must have been responsible for what was done. In modern times irrigation works in Egypt, India, and other parts of the world are certainly regarded as some of the outstanding things which engineers have accomplished, and play a very important part in food production and world economics generally.

Whilst the drainage and reclamation of land suitable for agriculture may not seem to be of such major importance as irrigation, they play a great part, and one has only to remember the drainage of the Fens in England and the reclamation of large areas in Holland. Although large individual works like these may appear more important, I think that, in the aggregate, when properly maintained, the minor drainage systems spread over the whole country have a greater economic effect.

It is quite a formidable task to renew old drainage schemes and restore them to working order. Often they were quite deep, and as ditches have been neglected and gradually filled in, the outlets of the drains to the natural watercourses can no longer work. Without consideration to the drainage of the land, road authorities have sometimes filled in the ditches alongside the roads, into which the field drains emptied, and it is now a difficult problem to find the best way to get rid of the water. So many of our country lanes, and even roads, were originally developed along the tracks of old watercourses which took the surface water away from the adjacent land.

Whilst it is an engineering problem to put these things right, the Government have recognised that it will not be done by the landowners without financial assistance and backing ; therefore grants of 50 per cent. of the cost of works are being made by the Ministry of Agriculture, and powers taken to insist on drainage schemes being carried out where considered necessary. This is all in addition to the establishment of Catchment Boards, and the reconstitution of the very old authorities who dealt with drainage and defence works called "Commissioners of Levels" and "Commissioners of Sewers."

Soil Erosion

To a very large extent the serious problem of land erosion, particularly in the United States, has been due to the ruthless denudation of trees from the land, so that wind brakes have been eliminated. In certain States where the trouble became most serious

* Institution of Civil Engineers : Presidential Address, November 3rd. Abstract.

and farmers fled from the area, the United States Government a few years ago started to plant trees in lines.

I doubt if many outside the comparatively limited circle, who are necessarily concerned, realise how far-reaching and disastrous the results of denudation have been, and the extent of the work which engineers and others are now being called upon to do to limit the damage that has recently been caused by erosion of the soil in many parts of the world.

We are aware that numerous civilisations have passed away, and that where they existed only barren wastes and ruined cities remain. The explanation is often given that the climiate has changed, but soil erosion then, as now, followed soil exhaustion. Profit and wealth can be most easily won by exploiting and exhausting the reserve of fertility in virgin soils. In North and South America the grassland soils require only superficial cultivation to convert them into fertile arable soils with a perfect tilth and rich in plant food, and in many cases they afford splendid pastures without having to be touched at all. After a period of continuous cropping without replacement of plant food, and by overgrazing, the land has often been reduced to a condition in which erosion has taken place to a disastrous and appalling extent by those who have used, not farmed, the land with labour-saving and yield-increasing devices.

Steam Power

With the development of steam power, the portable engine was rapidly substituted for the old horse gears, and for the fixed steam engines, which in some cases had replaced them to drive winnowing and threshing machines on the larger farms. The production of these portable steam engines and portable threshing machines increased very rapidly, and the firms who produced them not only supplied very large numbers in Great Britain, but also developed an extensive export trade to the Continent as well as to other parts of the world, so that for a time England led the world in this branch of engineering, very greatly helped by the Royal Agricultural Society by means of its annual shows and competitive trials, carried out by leading engineers of the day, of the various types of implements.

Then came the epoch-making invention of the reaper and binder, which was especially useful in the countries which were opening up large areas of virgin land and was developed to a fine degree of perfection in Canada and the United States of America, where the enormous home market enabled the makers to produce in such large quantities that they soon were in a position to become monopolists in the supply of these implements all over the world.

The Internal Combustion Engine

Whilst large-scale ploughing was done by steam engines, until the introduction of the internal combustion engine driven tractor the harvesting machines were usually drawn by teams of horses, though straw and wood-burning steam traction engines of light type were used to some extent.

The general adoption of the motor tractor cannot be said to have taken place until after Ford tackled the problem of producing, at a low price, a light, powerful tractor which could be used for ploughing and other operations during the last war. About ten years were required for it to supersede steam cable ploughing in Great Britain and be widely adopted. One must not overlook the fact that British agricultural engineering firms and others carried out considerable development work in connection with internal combustion tractors; but it was by the substitution of a light high-speed motor for the relatively slow and heavy ones which had been experimented with, that Ford, utilising the motor and gear-box in combination with the driving axle casing to take the place of a frame on which to mount them, can claim to have revolutionised tractor design.

Tractors

Although the simplicity of the wheeled tractor gives it many advantages when considerable powers are required for certain classes of work, the track-laying type of tractor can be made to do many things which are impossible for the wheeled machine; but conditions still exist under which the cable-hauled plough can do work which is impossible even with the track-laying type.

During the past few years the increase in the number of tractors employed by farmers has been enormous, and at the present time in England, Wales, and Scotland 119,000 tractors are being operated. On average land, one man with a Fordson or similar type of tractor with a two or three-furrow plough can do the work of three men with two-horsed ploughs, and a track-laying type of tractor with a four-furrow plough can do the work of five men with horse ploughs.

Farm Machinery

It is estimated that 20 million pounds was spent on new farm machinery in 1941, and that, as a result, Great Britain is now the most highly mechanised country in Europe, including Germany, which was credited with having had more than 3,000,000 H.P. According to data published by the Ministry of Agriculture, the tillage area has been increased by 4,000,000 acres, an increase of 36 per cent., since 1939, when the area under the plough was down to 11,000,000 arable acres. After the ploughing-up campaign during the last war, the area under the plough was for a short time increased to 14,567,000 acres.

Referring to the fresh scientific discoveries in connection with agriculture since he addressed the British Association as President of the Agricultural Section twenty years ago, Lord Bledisloe, after mentioning the various factors in inducing soil productivity, made the following remark: "And, above all, the labour and time-saving efficacy of modern farm implements and machinery." There can be no possible doubt that, without those implements, the increased area of arable land could not have been provided.

Reaping and Threshing

Whilst mechanical ploughing and cultivation of the land must take first place, the reaping and harvesting of the crops are now dependent on mechanical power. Owing to our climate, to reap and thresh at one operation is not such an easy matter as in some other countries; but with the limitation of available labour it is being done to an increasing extent, and the cost accepted of the artificial drying that will be necessary after threshing. It has been stated that 1250 combined reaping and threshing machines new to the country were brought into operation in 1941. Lord Radnor has written in connection with harvesting and grain drying: "The idea that combines were not suitable for the British Isles has been completely disproved. Used in conjunction with a grain drier the disadvantages of our climate are greatly reduced."

Whilst the ultimate object of agriculture is to produce human food, and the main products in which we are interested are corn, beef, and mutton, milk, and sugar, the farmer has to deal with a great many crops to produce them, having to provide the grass, hay, roots, and a variety of other crops to feed the cattle and to arrange a correct rotation of cropping to maintain his land in the most productive condition. All this necessitates the employment of a wide variety of implements besides the plough and the reaping machine.

Engineering Problems

The pipe drainage of land, when the trenches had to be dug by hand, was necessarily slow and expensive, and practically ceased during the years of depression. As a substitute, the mole drain was introduced, but that is applicable only to certain classes of land.

Modern power-operated trenching machines and pipe layers, the inception of which was due to Mr. George Watson, M. Inst. C.E., enable the work to be done at high speed with an enormous reduction in man power. Under average conditions a man will throw out 6 linear yards of trench, 12in. wide by 1ft. 6in. deep, per hour; the time taken for 1 mile of trench of similar section would be approximately 300 man-hours. There are various machines which will excavate 170 linear yards per hour, equal to 10 machine-hours per mile. The Government subsidy for pipe draining has been in operation since July, 1940, and in two years 14,780 schemes have been approved by the Ministry, at an estimated cost of £772,000, the area benefited being 113,600 acres. The Ministry estimate that applications received for grants in aid for tile drainage require 79,000,000 tiles per year, 1500 tiles being required per acre.

It is not so easy to make a direct comparison of the saving in man power by the employment of mechanical means for ditching and digging out watercourses and rivers which require opening up, but engineers are well aware of what can be done with the various types of diggers and drag-line excavators. To cite one example, since the war broke out schemes have been approved in Essex for draining 2120 acres, mole draining 59,110 acres, and clearing 2880 miles of ditches, 197,405 acres benefiting.

The mole drainer requires a heavy pull, and the caterpillar tractor has very greatly increased the possibilities of employing it. The caterpillar track has also made possible the employment of the various types of excavating machines on land, where it would have been impracticable to use mechanical excavators and diggers of the wheel type.

Ploughing

I must not occupy too much time with the details of the developments of the plough, which were made to reduce its draught and to turn a furrow without breaking up the soil. It seems to me that a useful paper might be read which was confined to plough design. In this connection Mr. Hudson, the Minister of Agriculture, recently expressed his surprise at finding the enormous number of different patterns of ploughs which were being made in the British Isles. No doubt a considerable number of varieties are required for the varying soil conditions and the different classes of work which ploughs are needed to do, but there can be no question that there must be a very great duplication of the necessary types by the manufacturers, with slight variations, which are uneconomic, not only in production, but also in necessitating the agents to hold stocks of so many different types.

(To be continued)

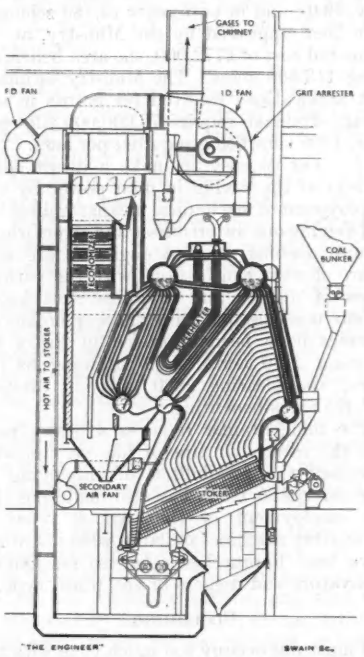
The Tacoma Bridge.—The dismantling of the Tacoma Narrows bridge, which collapsed two years ago, has been started to salvage the steel. The work is estimated to cost 300,000 dollars, but will save materials valued at 450,000 dollars.

Boilers—Past and Present*

By Colonel S. J. THOMPSON, D.S.O., M.I. Mech. E.

No. II—(*Continued from page 358, October 30th*)

FROM 1920 onwards we find pressures, rates of evaporation, and steam temperatures steadily climbing, and in 1924 it was quite common to see boilers of 75,000 lb. per hour evaporation installed, with steam pressures up to 325 lb. per square inch, and steam temperatures of 700 deg. Fah. By 1930 pressures between 350 lb. and 400 lb. per square inch were becoming fairly common, whilst the use of preheated air was largely adopted. At the present time steam pressures of 650 lb. per square inch are general, whilst many plants operate at 850 lb., and some even at 1500 lb. per square inch, and a few boilers work at even higher pressures. Steam temperatures have similarly increased until now temperatures of 850 deg. Fah. are normal, whilst in several instances temperatures of 900 deg. Fah. are employed, and in a few cases it is even higher, up to 960 deg. Fah. Similarly, evaporation rates have



Evaporation, 350,000 lb. per hour; working pressure. 850 lb. per sq. in.; feed-water temperature, 350 deg. Fah.

Fig. 9—Water-Tube Boiler and Mechanical Stoker

increased and boilers having a rating of 200,000 lb. per hour are now common, and there are several instances of ratings of 300,000 lb. to 350,000 lb. per hour, and a few in this country of the order of 550,000 lb. per hour. Figs. 9 and 10 show examples of these large boilers, the former being provided with a mechanical stoker, and the latter equipped for pulverised fuel. With these increases in steam pressures, temperatures, and evaporative capacities, progress has continued to be made in overall power station efficiency. Multi-stage feed heating is now invariably employed, and results in high feed temperatures to the boilers. This, in conjunction with high steam temperatures, necessitates the increased use of air heaters to enable the demand for higher boiler evaporation to be met. Figs. 9 and 10 illustrate typical water-tube boilers for 350,000 lb. of steam per hour, with mechanical stokers and pulverised fuel firing respectively.

An examination of modern boilers shows that water walls have been universally adopted. In the early development of water walls the main object was to avoid or reduce expensive brickwork repairs; but it has since been appreciated that their value as extremely useful heating surfaces is their most important advantage. Due to the effect of radiation, modern water walls are capable of very high rates of heat transfer, often 50 per cent. or more of the total heat being absorbed by the combustion chamber heating surface (Fig. 11).

I have already outlined the developments that have taken place in pressures, boiler capacity, steam temperatures, &c. Each new development has brought new problems to be overcome. The main difficulties may be summarised in the following five paragraphs.

(1) *Suitability of Material for Increasing Pressures and Temperatures.*—Metallurgical problems concerning the suitability of materials have arisen each time pressures have been raised or temperatures increased.

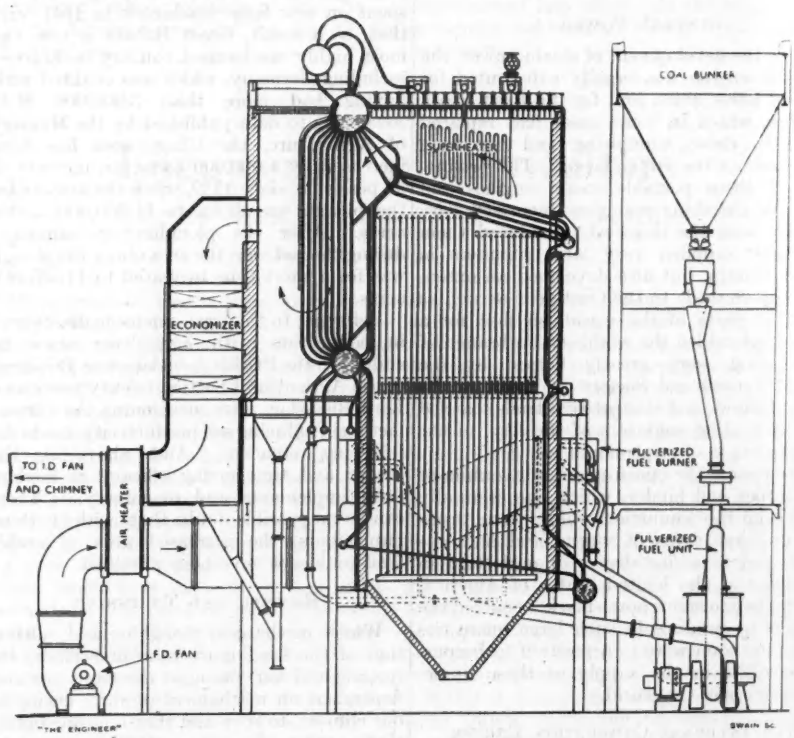
(2) *Resultant Feed Water Problems.*—Water problems arise as pressures have been increased. Additional precautions have shown themselves to be necessary to avoid scale formation and corrosion arising from complex chemical changes peculiar to each stage in rising pressures and temperatures.

(3) *Increased Combustion Chamber and Stoker Ratings.*—Increased rates of combustion of fuels have necessitated considerable attention to control of air supply and have brought about further problems in the form of secondary combustion, carry-over of grit, and deposits on the external surfaces of boilers, superheaters, economisers, and air heaters.

(4) *Increased Boiler Ratings.*—The increased capacities of boiler plant have brought about increased ratings in order to keep the overall size of plant within reasonable proportions. This has meant that the old-time simple unit fired by natural draught has had to give way to the much more complex plant with balanced draught, incorporating both forced and induced draught fans with their necessary driving motors and control equipment.

(5) *Increased Controls and Instruments Required.*—Larger boiler capacities have also necessitated the use of centralised controls and instrument panels, to enable the operator to visualise what is happening at all parts of his plant, very few of which are within his immediate range of vision. Years ago the only gauges with which a boiler was usually fitted were those for steam pressure and water level; now it is quite common to have extensive and elaborate instrument panels and kiosks carrying a multiplicity of the most ingenious mechanisms, complete with indicators, records, automatic visual and oral alarms, &c.

Whilst fully appreciating the necessity and the value of suitable instruments to enable the plant to be adequately supervised, it cannot be too highly emphasised that, having installed such delicate and expensive instruments, it is necessary to appoint a trained staff to keep them in working order, and to analyse and utilise their indications, otherwise the installation is of very little value. It must never be assumed that by installing a large number of instruments it is thereby possible to dispense with the services of a skilled operating staff for the boiler plant, and it must always be borne in mind that the instruments are simply there to assist the staff and to effect savings by centralising the controls. Incidentally, there are many other parts of the plant, besides the recording instruments, which require proper main-



Evaporation, 350,000 lb. per hour; working pressure, 850 lb. per sq. in.; feed-water temperature, 350 deg. Fah.

Fig. 10—Radiant Heat Boiler for Pulverised Fuel

* Institution of Mechanical Engineers, October 23rd, 1942: Presidential Address. Abstract.

tenance in order to secure full availability.

Many attempts have been made—to a great extent successfully—to develop automatic boiler control, but I cannot visualise any system which can entirely replace the skilled boiler-house operator. Automatic boiler control has many possibilities, and can, if intelligently applied and used, be of great assistance to a trained operating personnel. In this respect I might mention the development of automatic soot-blowing equipment, which has considerable possibilities, and should be of assistance in improving the availability of many boiler plants of complex design.

In large water-tube boiler units the various auxiliaries are apt to assume appreciable proportions, and there is a danger that boiler plant may become overloaded with auxiliaries. In addition to the usual equipment of economisers, mechanical stokers, and fans, further accessories have been embodied, such as vacuum plant for removing soot and grit from the boiler plant, ash conveyors, and much more extensive soot-blowing equipment, added to which in many cases automatic boiler control has been adopted, together with automatic control of soot blowers.

It may be interesting here to note that all this additional equipment has naturally affected the cost of the complete plant, and the following figures may therefore be of interest as showing the proportional cost of the various auxiliaries included in an average large boiler unit :—

	Per cent.
Boiler and superheater, &c.	44
Economiser	9
Air heater equipment	9
Draught plant	14
Mechanical stokers	12
Chimney, ash plant, vacuum plant, soot blower, &c.	10
Instruments and controls	2

The last item is variable and may increase to 7 per cent. in some cases.

Materials, Design, and Manufacturing Processes.—The general progress in boiler construction has necessitated the use of new methods of manufacture, in which increasing advantage is taken of the many special alloy steels developed by steel makers, which have properties of particular interest in the employment of higher pressures and temperatures. A considerable number of very high-class creep-resisting alloy steels, now available for high-temperature high-stress service, are used for tube supports, which are exposed to high temperatures and which must be highly resistant to scaling and creep during prolonged service. Other steels of lower alloy content give admirable properties, making them suitable for use as superheater tubes, which also must be resistant to creep and oxidation, both from the steam and the gas side.

Other steels now available combine strength with ductility at moderate temperatures and may find application in the manufacture of light-weight boiler drums; such steels have been in use for some years on the Continent, and their further development will be watched with considerable interest in this country.

When steam temperatures did not exceed 700 deg. Fah., a variation of 50 deg. Fah. up or down as a result of changes in operating conditions was not of any grave import, but such a variation cannot possibly be tolerated when using steam at 900 deg. Fah. or over. The creep strength of alloy steels is reduced at a rapidly increasing rate as temperatures increase and nothing like the margin permissible with low temperatures can be provided on materials in use at such high temperatures; an increase of even 20 deg. Fah. on the working temperature of 900 deg. Fah., if carried for some hours, might easily reduce the working life of the material by several years. For this reason considerable attention must of necessity be given to the close control of steam temperatures when operating at high temperatures, and various means are adopted for this purpose, such as the use of desuperheaters, gas or steam by-passes, separately fired superheaters, and control by recirculation of inert gas. The use of automatic apparatus is necessary to form an effective means of operating such controls as are provided, and this brings in its train further complication of plant.

In the new methods of construction, welding by various methods forms an increasingly important part. For example, welded drums have been in service on the Continent and in America over a considerable period. Following American and Continental experience, welded boiler drums made a somewhat belated appearance in this country. Increasing use is now being made of this method of fabrication, which has proved to be excellent in service. The electric metallic arc process is universally adopted, the actual welding being carried out either by hand or machine methods. Either system appears to be equally capable of producing satisfactory welds. The standard of welding required for Class 1 fusion-welded vessels, such as boiler drums, is very high. The

FIG. 12—X-RAY PHOTOGRAPH OF A POOR WELD

FIG. 13—X-RAY PHOTOGRAPH OF A GOOD WELD

FIG. 11—COMBUSTION CHAMBER, DEPTFORD POWER STATION

FIG. 14—ELECTRIC WELDING OF TUBE SLINGS

requirements of inspection are fully covered at the present time by various specifications; in fact, I suggest the time has now arrived when the different inspecting authorities should agree on one common specification. All specifications include radiographical or X-ray examination of the seams. The application of X-ray examination has probably done more to enable the fusion-welded boiler drum to be adopted than any other test. It is, moreover, a non-destructive test. After completion, electric-welded drums are heat treated; for this purpose the entire drum is placed in a furnace and raised to the specified temperature. The production of boiler drums to meet the very high standard set by the various specifications necessitates specialised technique and considerable experience.

Figs. 12 and 13 show X-ray photographs of a poor weld and a good weld respectively.

Forged shells with riveted ends, or complete forged shells, including ends, have also been adopted for high pressures, and a large number have for some time been in use both in this country and abroad, and have proved to be very satisfactory.

The welding together of tubular elements, also the prefabrication of pressure parts and the welding on site of complicated sections, are now recognised practice in the construction of certain types of boilers. Fig. 14 illustrates the electric welding of tube slings on site.

Recently a considerable amount of work has been done with the object of producing the ideal tube end joint in boilers, superheaters, and associated apparatus. From the earliest days of water-tube boilers the practice of expanding tube ends into suitable holes has been adopted as the most convenient method, and it is strange that until recently very little scientific research has been applied to this important essential. With the increased use of high steam pressures it has been found necessary to adopt improved forms of tube seatings. Grooved seatings have been provided with one or more rectangular, rounded, or V-shaped grooves, to improve the resistance to movement and to leakage; and various methods have been adopted in order to ascertain the correct amount of expanding, with the object of obtaining permanently tight joints whilst, at the same time, avoiding undue work-hardening by the over-rolling of expanded joints. The methods generally adopted have been:—

(*a*) The gauging of the tube diameter immediately next to the tube plate on the gas side of water-tube boilers.

(*b*) The gauging of the internal diameter of the expanded tube.

(*c*) The measurement of the energy input, which is then used to provide a measure of the amount of work done.

(*d*) The elongation method, by means of which the elongation of the tube in expanding is measured by extensometer.

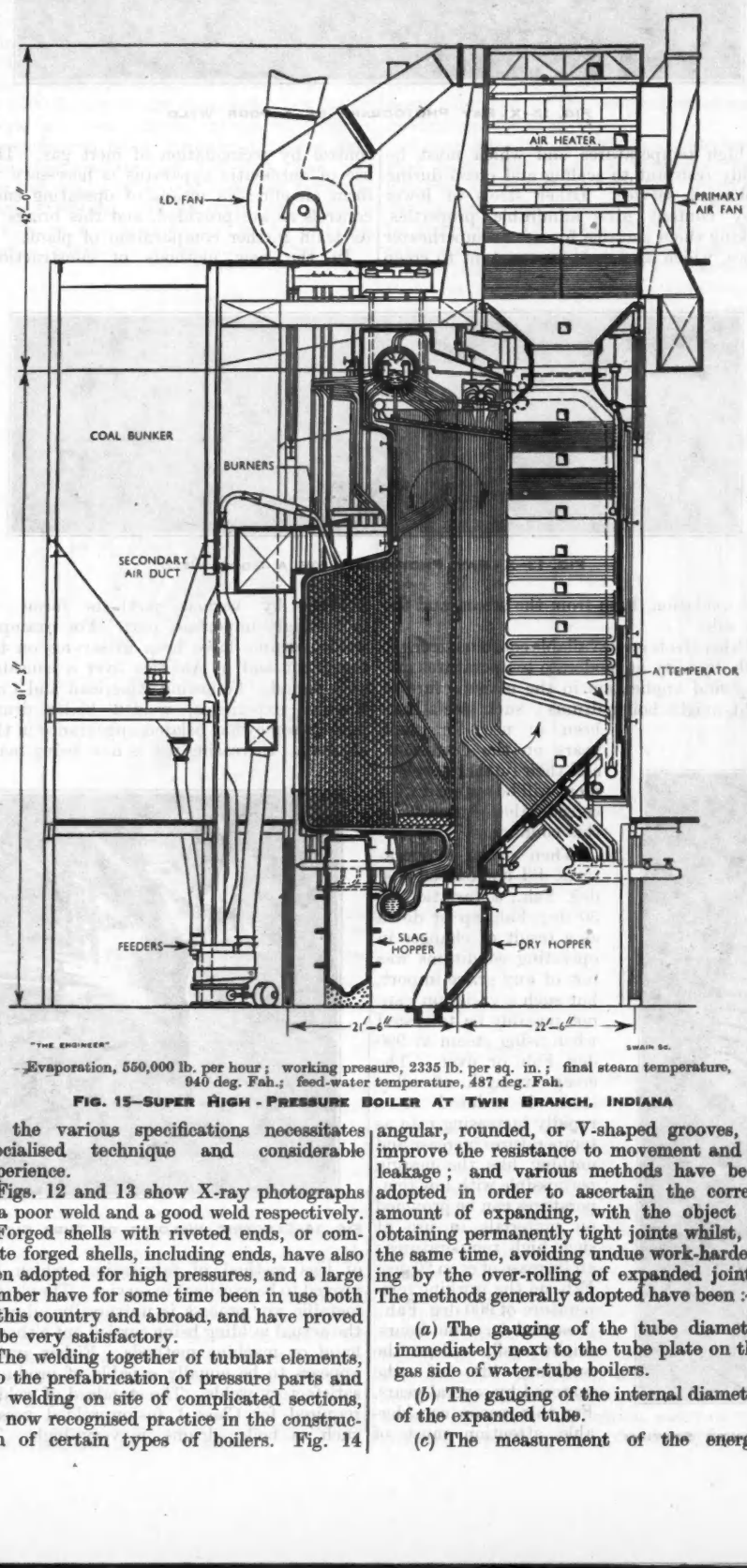
In a number of modern plants economisers and superheater tubes have been welded to stub ends provided in the headers; and in the case of a recent American installation the steam drum, which weighs 73 tons, is provided throughout with stub ends for the reception of welded joints. I understand that no expanded joints are used in this particular boiler, which is designed to produce 650,000 lb. of steam per hour at 2000 lb. per square inch working pressure.

The highest pressure natural circulation boiler ever installed has now been in operation for over 1½ years at the American Gas and Electric Company's Twin Branch Station, Mishawaka, Indiana. The previously existing Twin Branch Station plant consisted of two 40,000-kW units operating at 650 lb. per square inch pressure, the steam temperature being 750 deg. Fah. The new unit is a single boiler delivering steam at 2400 lb. per square inch pressure, 940 deg. Fah. steam temperature, to a 76,500-kW cross-compound condensing turbo-generator, the exhaust steam from the high-pressure machine being reheated to 900 deg. Fah. The boiler is capable of an evaporation of 550,000 lb. of steam per hour and is fired by pulverised fuel, using Indiana coal, which is high in moisture and ash.

The boiler unit consists of a primary furnace, first open pass, second open pass, main and by-pass convection section, economiser, and air heater. A spray type desuperheater is included for superheat control, and is located between the convection and radiant superheater stages, the reheat steam temperature being regulated by gas dampers. It is interesting to note that the steam drum is 54in. internal diameter, and 8·25in. thick, whilst full use is made of external downcomers, 28in. in diameter, which are fitted to the ends of the drum. Automatic control has been largely adopted, with telephone communication supplemented by a public address system to make it possible for key operators at all vital points to be in complete communication with each other.

It is stated* that an overall thermal efficiency of 33·49 per cent. has been obtained from this plant, whilst the combined availability of the boiler and turbine equipment over a period of three months was 88 per cent. The general lay-out of this outstanding boiler can be seen in Fig. 15. I understand that further new plant is projected† for the Twin Branch Station, which will include boiler plant and turbo-generators for operation at 1350 lb. per square inch working pressure.

(To be continued)



Evaporation, 550,000 lb. per hour; working pressure, 2335 lb. per sq. in.; final steam temperature, 940 deg. Fah.; feed-water temperature, 487 deg. Fah.

FIG. 15—SUPER HIGH-PRESSURE BOILER AT TWIN BRANCH, INDIANA

Obituary

ALBERT GEORGE HOOD

THOSE of our readers who are interested in shipbuilding and marine engineering will learn with sorrow of the death, on Sunday of last week, October 25th, at his home at Stockfield-on-Tyne, of Mr. A. G. Hood, the proprietor and editor of our monthly contemporary journal *The Shipbuilder and Marine Engine-Builder*. Mr. Hood, who was sixty-five years of age, had been confined to his bed for some weeks past, and had suffered indifferent health for some time. On Sunday

* *Electrical World*, 1941, Vol. 116, page 106.
† *Electrical World*, 1942, Vol. 117, page 1262.

evening his heart weakened, and he collapsed. Owing to an early infirmity in one of his legs, Mr. Hood could not get about very well, and since the introduction of petrol rationing he has been virtually a prisoner in his own home, and very rarely did he visit the offices of his paper.

In his early days he was the private secretary of the eminent shipbuilder, the late Sir George Hunter, chairman of Swan, Hunter and Wigham Richardson, Ltd., and part of his work in that capacity included the editing of the firm's house magazine. In carrying out this work Mr. Hood became interested in publishing and editorial work, and after some years he founded *The Mid-Tyne Link*. It succeeded and he developed the paper into *The Shipbuilder and Marine Engine-Builder*, entrusting its printing to Charles Birchall, Ltd., of Liverpool. His personal interest in the editing of the paper and his first-hand knowledge of shipbuilding and marine engines enabled him to develop that standard of work which we associate with our esteemed contemporary. More especially he produced several souvenir numbers, devoted to fully illustrated descriptions of outstanding British and foreign passenger liners, which were eagerly sought after by subscribers in all parts of the world. Right up to the end he continued to edit the paper personally and to take that absorbing interest in it which he did throughout the whole of his career.

His death will be keenly felt by many of his friends who came to know him in the shipping and shipbuilding industries, both at home and abroad.

JOHN MATTHEW BLACKWOOD STUART

THE profession of civil engineering has lost an outstanding member and the firm of Rendel, Palmer and Tritton, of Broadway, Westminster, a valued consultant, by the death of John Matthew Blackwood Stuart, which occurred on Saturday last, October 31st, following heart failure at his home, "Brooklands," Paddockhall Road, Haywards Heath, Sussex. Mr. Stuart, who was sixty years of age, received his education at Porter's Royal School and at Trinity College, Dublin, where he gained the degrees of B.A. and B.A.I. He served in the South African War with the North Irish Imperial Yeomanry, and in 1905 was appointed to the Indian Service of Engineers and posted to the Burma Irrigation Department as an Assistant Engineer. By 1914 he had attained the position of Executive Engineer. In the last war he served with the Queen Victoria's Own Sappers and Miners, and in 1919 he attained the rank of Major. In 1930 Mr. Stuart returned to Burma as assistant to the Chief Engineer and Under-Secretary to the Government of Burma. In 1923 he was made Superintendent of the Irrigation Branch, and in 1930 was promoted to the position of Superintending Engineer of the Irrigation Branch. Seven years later he became Chief Engineer of the Public Works Department, Irrigation Branch, and he retired from the Public Works Department in 1935.

Since then, on behalf of Messrs. Rendel, Palmer and Tritton, with whom he was associated as a consultant, he has undertaken several special services, the chief of which were, in 1935, an investigation and scheme for the reclamation of Huleh Marshes, Palestine, and in 1938 a survey and scheme for a new oil port on the Persian Gulf for the Anglo-Iranian Oil Company. For nearly two years past he had been actively engaged on the urgent work of the construction of an ordnance factory for the Government, and thus he died in harness.

He was a member of the Institution of Civil Engineers, and was the author of two publications, "Old Burmese Irrigation Works" and "The Sittang River and its Vagaries." His death at a comparatively early age will be mourned by many friends, both in this country and in Burma.

Engineering Cadetships*

VICTORY in a hard-fought war will never be won without courage; but the day has gone when courage alone can prevail. In the Battle of Britain "the Few" might not have secured the survival of "the Many" if they had not been given the "Spitfire" by the genius and labour of its designer and of the workers who built it and if our aircraft had not been kept in the air by skilled and devoted servicing. The Navy could not have carried out its prodigious tasks without the help of the secrets that our scientists have discovered and our engineers applied. In all its operations the Army depends not least upon the servicing of its tanks and other equipment.

All three Fighting Services are being given the best weapons in the world, but we need an ever-growing number of men to maintain and repair them. This is an engineers' war, and it is vital to our cause that we secure an adequate supply of technical officers. We are meeting immediate requirements from existing sources, but for the future we are instituting, in addition, a scheme of engineering cadetships.

Selection of Cadets.—Boys, aged 16, 17, 18, and 19, are invited to apply for engineering cadetships if:—

(*a*) They left school before October, 1942.

(*b*) They are not employed in any branch of engineering.

(*c*) They have obtained at least the School Certificate with a credit in mathematics *or* general science *or* physics; or (in the case of boys from Scotland) they have gained the Senior Leaving Certificate or satisfactorily completed not less than four years of an approved Senior Leaving Certificate course and have, in either case, shown proficiency in mathematics *or* science (including physics) *or* technical subjects.

Boys satisfying these conditions who make application for Engineering Cadetships will be considered for interview by a selection board on which all three Services will be represented. Those judged by the board to have the personality and other qualities required for potential technical officers will be accepted for cadetships subject to medical examination. On acceptance, cadets will be required to sign an undertaking to complete their training. This undertaking must be countersigned by the cadet's parent or guardian.

Training.—The training of cadets will be carried out under the directions of the education departments. So far as can be arranged, each cadet will attend a technical college near his home. Cadets will cover during their courses in the technical colleges the basic engineering science required in the associate membership examinations of either the Institution of Mechanical Engineers or the Institution of Electrical Engineers. During his training a cadet will be a member of one of the pre-Service organisations or of the Home Guard. Membership of a particular organisation will, however, not necessarily determine the Service in which a cadet will be commissioned upon the completion of his training.

Cadets will attend periodic lectures by Service officers and visits will be arranged to technical units and workshops.

Duration of Training.—Tenure of an engineering cadetship will be subject to satisfactory progress and conduct. Training will, as a rule, continue until the age of 20.

The length and character of the training of cadets will be adjusted to their age and educational qualifications. In general, cadets aged 18 or 19 will attend courses of training at technical colleges for 18 to 24 months; cadets aged 17 will attend similar courses for 2½ years.

Boys of 16 will receive preliminary instruction at an appropriate technical college or other institution.

When the grant of new engineering cadetship ceases, a cadet who has not then completed his training may be called upon to do so; if not so called upon and he wishes to complete the course which he has begun, his cadetship will be continued to enable him to do so.

Fees and Maintenance Grants.—The Government will pay the necessary educational fees and allow each cadet a maintenance grant of £140 a year (in London £160 a year) if he has to live away from home or £75 a year (in London £90 a year) if he lives at home.

Prospects after Training.—Upon the successful completion of his cadetship, a cadet will become a member of one of the Fighting Services and will receive special training in that Service. He will then be qualified to receive a commission as a technical officer. Every successful cadet will be equipped to give outstanding service to our cause in time of war and to obtain for himself a foundation for a professional career in time of peace.

Application for Cadetships.—The standard of ability and character required of cadets will necessitate very careful selection in the award of cadetships, but every boy who is eligible for consideration should not hesitate to make application at once for an engineering cadetship.

Forms of application can be obtained from the Ministry of Labour and National Service, Sardinia Street, London, W.C.2, or from any of the appointments offices. Requests for forms of application should be marked on the envelope "Engineering Cadetships."

* Circular issued by Ministry of Labour and National Service.

American Steel Industry

PRODUCTION of steel ingots in the United States during the first six months of 1942 reached approximately 42,700,000 gross tons, nearly 2,000,000 tons more than for the same period in 1941. For the entire year the output is estimated at 85,800,000 tons, the highest on record, comparing with about 32,000,000 for 1938; 53,000,000 for 1939; 67,000,000 for 1940; and 83,000,000 for 1941. A statement by the American Iron and Steel Institute says that the United States has been producing monthly as much as the Japanese can make in a year; in six days as much as Italy can make in six months; and probably three times the output of all European steel works now under enemy control. A political suggestion for the establishment of sponge iron plants, in view of the shortage of scrap, ignores the fact that experiments in recent years have been mainly discouraging, as the ores do not appear to respond to this treatment. Increased attention is being given to the recovery of metallic steel lost in slag and pit refuse, but at first it was not realised how great was this loss. Some plants are intended to recover steel in the refuse coming currently from the open-hearth furnace pits, while others recover it from old waste dumps. The use of flat-rolled low-alloy low-carbon steel in airship construction has released other metals for other uses. Certain of these alloys have 25,000 lb. minimum yield and 40,000 lb. ultimate strength, with 2 to 3 per cent. elongation in 2in. Others show 80,000 lb. yield and 85,000 lb. ultimate strength, with 6 to 9 per cent. elongation. Blast-furnace expansion in 1942 will increase pig iron production by 3,372,000 tons, with an additional 4,423,000 tons by July, 1943. Study of the situation shows that four steps are important for conservation of steel:—(1) To conserve the supply by using less; (2) to provide substitutes and so release metal for other purposes; (3) to reclaim what is ordinarily wasted in many ways; and (4) to develop greater standardisation in steel construction work.

The Engineer

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TOWED AIRCRAFT

ONE reads a good deal in these days of towed aircraft, and not infrequently one sees them in the skies. The glider observed to be towed by its flying tug at the end of a long cable is commonly a troop carrier of some sort. Many were used in the German operations in Crete, where, as it happens, they suffered huge casualties and proved much less effective than the enemy had hoped. Their effective troop landings were effected by other means. Some gliders are small craft and carry only a few men with their equipment, but some are quite large; indeed, certain German ones are so huge that they must be hard to manage, especially during take-off. It is natural to ask what useful purpose is served in wartime by such combinations, in comparison, let us say, with the powered aeroplane designed to carry troops. One is that the latter can then be saved from the need to land on what may well be hostile territory. Such landings are always risky; even if a prepared aerodrome is available it may have been badly bombed already, and once the aircraft is damaged its useful career is at an end. It can bring no more troops. A tug, however, can slip its glider when the latter is within easy range of its destination and go back for a fresh load. If the glider is damaged by a poor landing it does not much matter, since it was not expected to fly again during that phase of the operations. If, of course, the landing proves so heavy as to incapacitate the troops carried, that is a misfortune, but at least no worse than would have happened had a troop-carrying aeroplane been employed instead. Moreover, the gliders are vastly cheaper to construct and can therefore be more readily risked. Being more lightly laden for its wing area, the glider will also land at a lower and safer speed.

These are evident operational advantages, but engineers will naturally ask whether there is also some technical gain in flying efficiency or in fuel economy in the tug-glider combination. At first sight it hardly seems that there could be, since modern aircraft, when flying at their most economical cruising speeds, experience much the same drag in pounds per ton. Published information about aircraft built in almost any part of the world shows that a gliding angle of about 1 in 15 is just attainable, corresponding to a drag force of about 150 lb. per ton—not very different as it happens from that experienced by road transport vehicles, despite the enormous difference in speed. Can there, then, be any technical gain in dividing the total flying weight of a large troop-carrying aeroplane into two parts, tug and glider? If both alike experience a drag of the same number of pounds per ton, there can be no fuel economy gained by the division. But this does not carry one all the way; the glider, having no airscrew ahead of its wing, gains the advantage that the air flow will not have had a previous churning up by airscrew blades and will therefore be more laminar in its pattern and less turbulent, with a consequent useful reduction in the drag force. How far this saving in drag can go will depend on the wing shape chosen and upon the care taken in construction to present the smoothest possible surface to the air stream. In so far as a reduction in drag is attained in this way, the less will be the overall resistance encountered by the combination; though account must needs be taken of the resistance of the connecting cable, whose slope relative to the air will depend upon the operational positions taken up by tug and trailer. When the appropriate allowances are made it would seem that the purely technical advantages of the one system over the other cannot be considerable, though the operational advantages already mentioned still, of course, stand good. In past years much study has been given to the stability in flight of powered aircraft. It is a troublesome piece of mathematics; but, thanks to the perseverance of aeronautically minded mathematicians, a solution on general lines has been attained and there is no great difficulty nowadays in designing aircraft with any desired degree of inherent stability. But when one has to take into account the towing cable which provides the pull for the glider, the equations become very complex and much harder to handle. A substantial degree of stability in flight must needs be provided, since any rapid pitching and rolling motion would not only be trying to the troops, but might render them ineffective as fighters during the vital minutes after landing. No doubt all countries which build such craft will do their best to raise the standard of their performance in that as in every other way.

When peace comes once more and cargo-carrying aircraft are used on a large scale for the conveyance of specially valuable goods or those very urgently needed, one may expect to see lines of load-carrying gliders hauled by tugs, the individual gliders slipping their cables one by one as they approach their desired ports of landing. Much transhipment will thus be avoided and that is an immense convenience, even though the cost of conveyance per ton-mile be high.

Engineering Cadets

DURING the past week in the daily Press and on the wireless announcements have been made of a new scheme for the technical education of "cadets" who at the end of their period of training will enter the Armed Forces, and in due course become technical officers. On another page of this issue we give particulars of the scheme as it applies to youths of eighteen, seventeen, and sixteen years of age, and of the educational qualifications required of those who enter for it. Candidates must also satisfy a selection board in a personal interview that they have already, or appear likely to develop, the personality and other qualifications necessary in those who, as in this scheme, are destined for commissioned rank. If accepted, they become in all but name members of H.M. Forces, in that the Government not only pays for their education, but provides a maintenance grant in return for a written undertaking that each candidate will complete his term of training. There is, we understand, room at the technical colleges which are to provide the training for an intake of several thousands of cadets each year. The Institution of Mechanical Engineers has already announced that, subject to certain safeguards, candidates successfully completing the course will be exempted from the necessity of taking Part B of its associate membership examination, and the Institution of Electrical Engineers is giving sympathetic consideration to a similar concession. The training that is to be given is expected therefore to reach a high standard, and, in conjunction with the practical experience to be gained in the Armed Forces, seems likely to fit candidates for a professional career when the war is over.

No one who studies the details of the scheme can doubt the advantages it offers to young men who enter for it. But whilst the young may therefore be expected to welcome

the scheme and the Services to give it their blessing, it is reasonable, we think, for engineers to regard it rather in the light of an experiment and to reserve judgment upon it until its results can be properly assessed. For while those entering the scheme at sixteen years of age take a three and a half year course, including two periods of six months each in engineering works or Government training centres, cadets of eighteen are to complete their training in a length of time surprisingly short in relation to the standard it is hoped to attain, and will receive no more practical experience than can be provided by visits to works and practice in the college workshops. The rapidity with which it is hoped to train these young men is, we understand, partly accounted for by an increase, as compared to peacetime usage, in the number of hours worked per week and partly by a considerable increase in the number of weeks worked per year. Yet when it is remembered that many peacetime students found it necessary to put in quite long hours on homework and to burn on occasion quantities of midnight oil, it is perhaps legitimate to wonder whether the increase in the hours worked per annum is really as great as it appears at first sight to be. It also deserves notice that nearly half the time at the colleges is to be devoted to practical workshop training. We have already heard engineers express doubts as to the practical ability of the new cadets when they leave the colleges, and it is certainly very much to be hoped that they will be given plenty of opportunity once they have joined the Armed Forces to gain practical experience. For, with some knowledge of workshop training as given by colleges before the war, we find it difficult to believe that it is anything but an inefficient substitute for experience in a works. Many practising engineers are likely to feel such doubts, and only the continued success of the scheme after the first cadets have passed through the course in two years' time can resolve them, however much those same engineers may hope that the beliefs of the originators of the scheme will be justified.

As is by now well known, the State Bursary Scheme and the Intensive Training Scheme are already producing considerable numbers of trained engineers. It is also only too well known that substantial numbers of young engineers have been, and are still being, taken away from civilian employment to become technical officers in the Armed Forces. As Lord Hankey, Chairman of the Technical Personnel Committee, pointed out in his broadcast last Monday night, those sources of supply to the Forces cannot indefinitely be depended upon without adversely affecting the output of munitions of war. Yet as the Navy, Army, and Air Force become more and more fully equipped with all the very many mechanical and electrical devices used in modern war, it becomes increasingly essential, if proper use is to be made of those devices, that there should be a liberal supply of trained officers to care for their maintenance and repair. In earlier stages of the war emphasis lay mainly on production. Now maintenance is assuming as great an importance, and the new cadet scheme is designed to provide the necessary officer personnel, and, at least to some extent, to relieve the munitions industries of the necessity to do so. One further comment may be made. To some, it may seem that the scheme has been developed on the basis of a pessimistic estimate of the duration of the war, in that cadets will not be ready for service in less than eighteen to twenty-four months from the present date. Yet though we may, with some justification in recent events, hope that the war, at least in Europe, will be victoriously concluded before that time, it is but elementary wisdom to provide now for future needs, lest in gambling upon our hopes we find ourselves still in 1944 fighting at a disadvantage.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE ELECTRIC ARC FURNACE

SIR,—I have read Dr. T. F. Wall's articles dealing with the arc furnace with considerable interest. His treatment of the electrical problems involved and much of his descriptive matter is admirable, but there are certain inaccuracies which should not be allowed to pass without comment.

In the first place, the articles—apart from the discussion of principles—savours of German practice from beginning to end. Developments and achievements in this country and in America are equally, if not more, creditable, and the information lacks completeness by these omissions. For instance, the author refers to the direct-arc furnace as being built in sizes from ½ to 35 tons, whilst in actual fact it is being built in sizes ranging from 25 lb. to 100 tons. In America there has been a considerable demand for furnaces of 50 to 75 tons, with kVA ratings of 10,000 to 15,000, and quite a number are in operation.

The all-hydraulic lift and swing-aside roof furnace for rapid charging, now built in sizes of up to 60 tons, is not even mentioned, whilst prominence is given to the German development of the furnace with a rotating body—an innovation of questionable benefit.

In the second article Dr. Wall makes a statement that the high-frequency furnace will become a formidable competitor of the arc furnace for producing ferro-alloys. Such a statement can find no support in theory or practice, since these alloys are only reduced from their refractory ores at temperatures between 2000 deg. and 3000 deg. Cent. It is inconceivable how such reactions could be effected in a high-frequency induction furnace on any scale, whilst still retaining a good coupling and an adequate refractory thickness. The suggestion is too illusory to warrant further comment.

The metallurgical information contained in the second article is rather confused, and the terms "smelting" and "melting" are misused. In dealing with cast iron the author states that gas and sulphur content can be reduced to 0·01 per cent. No manufacturer would ever dream of removing sulphur in cast iron (presumably by a carbide slag) to 0·01 per cent. It would be far too costly to do so and generally an adequate sulphur removal can be effected in the ladle with soda ash. Except under very exceptional circumstances the only "refining" of cast iron normally done in the electric furnace is refining of the ultimate graphite structure by superheating and alloying. The author's information on the production of ferro-chromium is entirely out of date, since the alloy is being made with a carbon content of below 0·1 per cent. and with a consumption of less than 15,000 kWh per ton against the author's figure of 27,000 kWh.

In the third article the information on electrodes is not entirely accurate. Carbon electrodes are not particularly brittle, and I do not believe that oxidation starts appreciably at 300 deg. Cent.—a temperature of 500 deg. Cent. would be more accurate. Neither is graphite paste required to bed the clamp on to the electrode surface. I have had experience of a large number of such furnaces equipped with carbon electrodes and this has never been necessary. A graphite paste is, however, needed for joining the electrodes with nipples.

The ingredients of the Soderberg electrode paste are not very explicitly defined. The anthracite and/or coke must be calcined and must be crushed and graded to be successful. A mixture of pellets and powder would not be sufficient.

In regard to electrode control, I am surprised that Dr. Wall finds that hydraulic equipment is cheaper than all-electric control. My experience is that the reverse is true.

In the fourth article the manufacture of calcium carbide is described and the impression might be gained that 1 ton of carbide yields 300 litres of gas. The author has omitted to state that the yield refers to 1 kilo. of carbide. He also deals with the possible recovery of CO from the furnace. This recovery is being practised on a large scale in certain American and Canadian plants, but is only economical and practicable in large furnaces above about 15,000 kVA, owing to the complications involved and the additional cost of gas cleaning and recovery.

It is stated that in ferro-alloy manufacture the hearth lining is different from that used for calcium carbide. The reverse is actually correct, since most ferro-alloys are made on carbon bottoms.

The author also states that ferro-silicon is added to steel to remove oxygen and to eliminate slag inclusions. The addition of ferro-silicon to steel containing oxygen actually produces inclusion, but it reduces the gas content of the steel subsequently cast.

In spite of these criticisms, the articles will serve to give the engineer a better appreciation of the principles of arc furnace construction and operation.

A. G. ROBIETTE,
Chief Metallurgist.
Birmingham Electric Furnaces, Ltd.,
Birmingham, October 23rd.

SIR,—I appreciate the complimentary remarks on my articles in the first and last paragraphs of Mr. Robiette's letter and the information which he gives with regard to some aspects of United States and Canadian practice is of considerable interest.

There are two items of the critical comments, however, which I think are of importance, and those are the references to the prospect of producing ferro-alloys by means of the high-frequency furnace (paragraph 4) and the reduction of the gas and sulphur content during the manufacture of cast iron (paragraph 5). In this connection, the following (translated) extract from the *Elektrotechnische Zeitschrift*, 1936, page 1145, is pertinent: "Recently, it has been found possible to produce ferro-chromium

more cheaply in the high-frequency furnace than in the electric arc furnace." On page 1145 of the same issue will be found the statement to which Mr. Robiette objects with regard to the removal of gas and sulphur content from cast iron.

If Mr. Robiette had said that my articles savour of Continental practice I would not quarrel with this description. Those of us who are deeply interested in the design, operation, and applications of this type of furnace would welcome access to information as to British practice and achievements in this field, and if my articles promote the publication of more detailed accounts of British work in connection with electric arc furnace technique than have yet appeared, they will have fulfilled a useful purpose.

T. F. WALL.

The University, Sheffield,
October 31st.

THE STATUS OF ENGINEERS

SIR,—I read Professor Inglis' broadcast printed in your issue with surprise, admiration, and regret.

My surprise was occasioned by the proposal to limit the use of the word "engineer" to those who "plan, organise, and scientifically conceive." I imagine that would disfranchise you and I alike, and many thousands of others. What the Continental engineers do about it does not seem to matter at the present moment. The largest group of them is engaged on a diabolical attempt to enslave mankind, and the sooner the whole of the members of the V.D.I. are killed or captured, so much the better for mankind.

The reasons for my admiration are unnecessary to dwell on. I listened to and read the fine accounts of the work of the Italian, Swiss, and American engineers with great pleasure.

My regret was due to the fact that the occasion was used for propaganda and for airing a grievance.

Professor Inglis spoke to the general public as the head of the engineering profession and also as an eminent engineer. He seemed dissatisfied that the fine work done by engineers had not led to political leadership. One sentence reads with but slight alteration: But if you want *us* to come into the open as *we* certainly should, and take a leading part in the new order *we* have created, *we* must be offered something more tempting than an occasional invitation to serve on a Government advisory committee." Is that how Mr. Churchill, Mr. Morrison, Mr. Eden, or Mr. Bevin would talk? Public office follows public service, and if engineers do not enter public life, then they can have no cause for complaint. Why are there not a score of eminent engineers in Parliament? Three Presidents of the Institution of Civil Engineers at least—Robert Stephenson, Locke, and McClean—could put M.P. after their names. Other engineer M.P.s were Sir Edward Reed, Sir Lowthian Bell, Sir Mark Palmer, Sir Benjamin Hingley, Sir William Pearce, James Kitson, and so on. Whether great engineers would make successful statesmen, no one can say. You can hardly imagine Watt, Trevithick, or Sir Charles Parsons members of a Cabinet. The only notable instance I can recall of an engineer becoming a great man in public affairs was the famous Carnot, organiser of the French Republican Armies. His first step, however, was to gain a seat in the Legislative Assembly.

EDGAR C. SMITH,
Engineer-Captain, R.N. (Rtd.).

Horley, November 2nd.

SELF-PHASING OF LOCOMOTIVES

SIR,—I notice that a correspondent has again raised the question of synchronising in bogie locomotives. This point was originally mooted by Mr. Livesay in connection with L.M.S. "Garratt" locomotives, but so far as I can recollect it was never proved. Mr. Livesay stated, so I believe, that as a result of two runs of some 150 miles each he was of the opinion that the two engines tended to synchronise. Subsequent correspondents assumed that synchronism did, as a matter of fact, take place, and attempted to find possible causes for it happening.

I am not a locomotive engineer, but am, nevertheless, definitely interested in locomotives; furthermore, I reside within 2 miles of the L.M.S. (Midland) main line, and work within a stone's throw of it. It is my considered opinion that synchronism does not take place normally. Dozens of times I have seen these locomotives brought to a stop very gently when hauling heavy loads and, when stopped, the cranks have been at "any old angle" relative to each other. From my house at night it is an easy matter to pick out "Garratts" by their most characteristic exhaust beat, which I can best describe as tum-tum, tum-tum, tum-tum, &c. Were the two engines in synchronism the exhaust beat would, of course, be the same as that of a normal two-cylinder locomotive. The above and other observations have led to the formation of the above opinion, which is shared by others to whom I have mentioned the matter.

G. A. PICKETT.

Biddenham, Bedford, November 31st.

GURNEY'S BOILER

SIR,—There appears to be a slight mistake in Colonel Thompson's interesting paper on boilers. According to Gordon's "Treatise upon Elementary Locomotion" (pages 141 and 142 of the second edition), the boiler shown in Fig. 6 was "Mr. Gurney's last arrangement," and the one in Fig. 7 was an earlier pattern. The one in Fig. 6 is also illustrated in Mr. Rhys Jenkins's "Motor Cars" (page 74), and called "Gurney's boiler (final form)."

C. F. DENDY MARSHALL.

Wonersh, Guildford, October 31st.

Sixty Years Ago

SECONDARY BATTERIES

IN 1881 Sir William Thomson startled the scientific world by announcing that he had carried from Paris to Scotland a small box in which were stored upwards of a million foot-pounds of energy. The box actually contained a Faure secondary battery which had been charged in France and taken by Thomson to the physical laboratory at Glasgow University. The announcement seized the imagination of the general public, who saw in it something which seemed to be of tremendous import for the future of civilisation. It was now possible, it was said, to store up great quantities of electricity in deal boxes. On the basis of that crude conception, companies were soon being formed to construct and sell accumulator batteries, and to them the public readily contributed funds. On several occasions we sought to place before the public the true implications of Thomson's statement. Our chief difficulty appears to have been to impress upon the uninitiated the relative insignificance of a million foot-pounds of energy. It was largely in vain that we said that it was no more than was contained in a few ounces of coal. The public was fascinated by the figure of a million and was largely indifferent to the magnitude of a foot-pound. In our issue of November 10th, 1882, we returned once more to the subject. We approached it from a different angle. The Faure battery, we said, embodied no new scientific principle. In 1859 Planté, of Paris, had made a storage battery consisting of two lead plates immersed in acidulated water. The improvement effected by Faure consisted simply of coating the plates with red lead to begin with. In doing so, he had merely adopted a suggestion made by Fitzgerald in 1863. Faure's only contribution to the development of the secondary battery consisted of the means and methods employed in its manufacture. To this exposure we added the somewhat subtle statement that no electricity at all was stored up in a charged secondary battery. Our argument was that the only difference between a charged and an uncharged battery consisted in the difference in the chemical composition of the two lead plates, and that the energy stored in the charged battery was not electrical, but chemical. Finally, we endeavoured to warn the public that the progress of scientific discovery would in all probability soon leave the Faure battery far behind, and that that battery was still in the earliest experimental stage.

BOOKS RECEIVED

Magnetic Crack Detection. By G. B. Young. London: Charles Griffin and Co., Ltd., 42, Drury Lane, W.C.2. Price 2s. 6d. net.

Inchley's Theory of Heat Engines. By H. W. Baker. London: Longmans, Green and Co., Ltd., 43, Albert Drive, S.W.19. Price 16s. net.

Aeroplanes in Detail. From the original drawings by J. H. Clark. London: Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 2s. 6d. net.

Practical Engineering Problems and their Solution. By F. H. Higgs. London: Longmans, Green and Co., Ltd., 43, Albert Drive, S.W.19. Price 1s. net.

High-Speed Diesel or Compression Ignition Oil Engines. By A. H. Goldingham. London: E. and F. N. Spon, Ltd., 57, Haymarket, S.W.1. Price 15s. net.

Fatigue of Metals: Some Facts for the Designing Engineer. Second edition. By D. Landau. New York: The Nitralloy Corporation, 230, Park Avenue.

Machine Shop Practice. By W. H. Durney. Second edition. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 7s. 6d. net.

Practical Aircraft Stress Analysis. Third edition. By D. R. Adams. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 8s. 6d. net.

The Costing of Government Contracts. By L. W. Robson. London: Gee and Co. (Publishers), Ltd., The City Library, Basinghall Street, E.C.2. Price 1s. 6d.

Fifth Progress Report of the Welding Research Council. London: Institute of Welding, 2, Buckingham Palace Gardens, Buckingham Palace Road, S.W.1. Price 5s. net.

Engineering and Aircraft Limits, Fits, and Tolerances. By H. Parkinson. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 2s. net.

Government Contract Cost Investigations. By F. R. M. de Paula. London: Gee and Co. (Publishers), Ltd., The City Library, Basinghall Street, E.C.2. Price 1s. 3d. net.

The Mechanical Testing of Metals and Alloys. Third edition. By P. F. Foster. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 18s. net.

Reference Book of Aircraft Wheels, Brakes, and Oleo Struts. Second edition. By D. Vine. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 1s. net.

Technique for the Gas Welding of Rolled Aluminium and of Aluminium Alloy Castings. Second edition. London: Institute of Welding, 2, Buckingham Palace Gardens, S.W.1. Price 1s. 6d. net.

Understanding Basic Engineering by Question and Answer. By W. Hazell. London: The English Universities Press, Ltd., Little Paul's House, Warwick Square, E.C.4. Price 2s. 6d. net.

Steel Manufacture Simply Explained. Second edition. By E. Gregory and E. N. Simons. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 7s. 6d. net.

The Naval Architect's and Shipbuilder's Pocket-book. Fourteenth edition. By C. Mackrow and L. Woollard. London: The Technical Press, Ltd., Gloucester Road, Kingston Hill, Surrey. Price 30s. net.

An Introduction to Aeronautical Engineering: Vol. III, Properties and Strength of Materials. By J. D. Haddon. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 8s. 6d. net.

On the Origin of the Internal Combustion Engine

By A. K. BRUCE

IN the preface to his well-known work, "Das Entwerfen und Berechnen der Verbrennungskraftmaschinen" ("The Design and Construction of Internal Combustion Engines"), Hugo Güldner makes the following claim: "Alles was den Motorenbau begründet, was ihn lebensfähig und gross gemacht hat, ist in deutschen Köpfen ersonnen oder auf deutschen Boden zuerst verwirklicht worden." The translation is as follows:—"Everything that has served to lay the foundations of the [internal combustion engine] industry and that has helped to make it vital and important is either the product of German thought or was first made practical on German soil." Both assertions are untrue, though they have been sedulously circulated for the last forty years. It is high time that engineers and engine users throughout the world, too many of whom have been misled by such fallacies as those set forth by Güldner and others, should be made more familiar than they are with the actual facts.

The truth is that the internal combustion engine has its foundation in the practical work of a small group of individuals, none of whom were Germans. The first really conspicuous bricks were laid by John Barber, an English country gentleman of Standsby, in the county of Derby, though he lived for what seem to have been his most active inventive years at Attleborough, in the parish of Nuneaton. On October 31st, 1791, Barber received grant of Patent No. 1833 for "A Method of Rising Inflammable Air for the Purposes of Procuring Motion, and Facilitating Metallurgical Operations." The specification describes and illustrates a crude form of constant-pressure combustion turbine, to be used (as explained in annotations on the drawing) for "procuring motion and facilitating metallurgical operations, and which may be applied to the grinding of corn, flint, manganese or other matter, also to rolling, slitting, forging, and battering iron and other metals, turning of mills for spinning and engines for turning up coals, minerals from mines of all sorts, stamping of ores, raising water, and any other motions that may be required."

This patent of Barber's contains not only the earliest-known description of a combustion turbine, but describes the first attempt to obtain motive power from inflammable gas derived from the distillation of coal, wood, and other substances. Barber mentions, moreover, the compression of inflammable gas and atmospheric air prior to ignition, and he apprehended the important fact that the inflammable gas and air should be in certain proportions. In all, five patents were applied for by Barber between the years 1766 and 1792, though only his 1791 patent is of material interest as concerning internal combustion engines. Other of his patents show, however, that he possessed a wide knowledge of the mining and metallurgical practice of his day and that he was well acquainted with the atmospheric steam engine.

Rather less than three years from the date of Barber's patent, Robert Street, a varnish manufacturer, residing at Providence Row, in the parish of Christ Church, Surrey, received grant (May 7th, 1794) of a patent (No. 1983) describing an atmospheric gas engine comprising a motor cylinder and piston. This was not the first use of the piston and cylinder as a means for obtaining power from a gaseous explosion, since Christiaan Huygens, the Dutch mathematician and physicist, had experimented during the seventeenth century with a gunpowder engine of piston type. Street's piston gas engine, extremely crude though it was, has, however, the distinction of being the first reciprocating internal combustion engine in which can be recognised the features of practical utility. The engine as described in the patent specification was non-automatic in action, induction and ignition being controlled by hand. For fuel, the inventor mentions "spirits of tar or turpentine," thus suggesting that he had experimented with materials known to him in his industry as a manufacturer of varnish. Had Street developed this engine a few years later, more might have been heard of it, since in 1798 William Murdock, James Watt's brilliant assistant and collaborator, installed at Soho, Birmingham, the first commercial installation for the production of illuminating gas. Murdock had for some years been experimenting with gas distillation, probably, indeed, from his boyhood; but he did not, as some have supposed, discover coal gas, which seems to have been first described—with any degree of precision—by the Reverend John Clayton, Dean of Kildare, the date being in or about 1739. Later, in 1767, another clergyman (the Reverend Dr. Richard Watson, afterwards Bishop of Llandaff), made a more detailed examination of coal gas, and drew attention to its great inflammability. To Murdock, however, is justly ascribed the practical foundation of the gas industry, and it is not too much to say that if he had happened to concentrate on the power-producing potentiality of illuminating gas, and been able to carry Watt and Boulton with him in the work, the subsequent history of both the internal combustion engine and the steam engine would have been profoundly affected.

Prior to the date of Murdock's small gas-works installation at Soho, a Frenchman was investigating the illuminating and power-producing characteristics of gas distilled from wood and coal, and he is believed to have used the gas for illuminating his house in Paris. This Frenchman (Philippe Lebon d'Humbersin) received grant on August 25th, 1801, of a patent relating to "La construction des machines mues par la force expansive du gaz," which described a gas engine of double-acting type and outlines the idea of compression in the piston gas engine. Lebon d'Humbersin appears, moreover, to have been the originator of electric ignition, and there is no doubt that he was, at the commencement of the nineteenth century, acquainted with some of the vital requirements of the internal combustion engine. To this early date belongs also the work of another Frenchman, J. L. Gay-Lüssac, who, in 1809, published his "Mémoire" on gaseous combination. This was an era of many happenings in France, since, apart from such momentous events as the French Revolution and the Napoleonic Wars, Nicolas-Léonard Sadi Carnot was born in 1795 and Alphonse Beau de Rochas in 1815. Both these Frenchmen were destined to have a profound influence on the development of the internal combustion engine, one as a speculative scientist of great originality and the other as a practical mechanical engineer of exceptional sagacity.

The year 1823 must be mentioned, since, on December 4th, Samuel Brown, then of Printing House Square, Blackfriars, received grant of his first patent (No. 4874). In the specification Brown claims "to be the first and true inventor of that combination for effecting a vacuum with inflammable gas, however much it might be varied by the mechanical means with which it may be used." He shows a gas engine with vertical water-cooled cylinder, ignition being by flame. Brown, like others before him, had studied very closely the features of the atmospheric steam engine and has the distinction of designing and building the first internal combustion engine which reached the stage of actual utility. The first engine—apparently a model—built by Brown was known as a "pneumatic" engine and operated without a piston. In 1825 Brown had considerably improved the arrangement, embodying a piston which he found "to answer his most sanguine expectations." The engine then became known as a "gas vacuum engine." In 1826, Brown (then described as of Old Brompton, Middlesex) received grant of a further patent (No. 5350), in which he details "Certain Improvements on my former Patent." The specification is of interest for the reason—among others—that Brown states that he has found "from experience" that he can use gas "in combination with atmospheric air, which is attended with great advantage, since, when so mixed, it unites more readily and produces as perfect a vacuum with a much less expenditure of gas." He also claims "the exclusive right" of using, in addition to "hydrogen gas or inflammable air," the "ignited steam or vapour of boiling alcohol or ardent spirit, essential oils, naphtha, and all other articles capable of producing inflammable steam or vapour" for the purpose of working his engine.

Just at the time Brown was struggling in London with his "gas vacuum engine," Carnot, in Paris, published (1824) his "Réflexions sur la Puissance Motrice du Feu," which were subsequently expounded to the scientific world by the French physicist Clapeyron and the British physicist William Thomson, afterwards Lord Kelvin. It is a coincidence that William Thomson was born in the year which saw the publication of Carnot's "Réflexions." Seventy-three years later he tendered the advice which, based on his familiarity with the reasonings of Carnot, led Mirrlees Watson and Yaryan, of Glasgow, to construct a Diesel engine.

The first quarter of the nineteenth century was marked in Great Britain, as in France, by great scientific and industrial activity. Faraday was in his prime, and among other things he had communicated to the Royal Society (1823) some papers on the characteristics of certain gases. These papers seem to have suggested to Mark Isambard Brunel, his carbonic acid gas engine patented in 1825. Two years later, in 1827, a Scottish parish minister—the Reverend Dr. Robert Stirling—and his brother (James Stirling) received grant of patent No. 5456 relating to an improved hot air engine, the distinguishing characteristic of which lay in the employment of a regenerator. In this patent the regenerator made its first appearance, an inventive step which led later to the use of the regenerator in metallurgical and other processes, notably by Siemens. The parish minister and his brother may also be said to have made the earliest application of

pressure charging, since the fourth claim in patent No. 5456 covers the use of an air pump for forcing through the valves "a greater quantity of air than could be introduced by the simple pressure of the atmosphere." Perhaps it should here be added that the hot air engine was first described by a Yorkshire baronet, Sir George Cayley, his account of "An Engine for affording Mechanical Power from Air Expanded by Heat" being printed during 1807 in Nicholson's "Journal of Natural Philosophy, Chemistry and the Arts."

In 1833 (one year after the birth of Nikolaus August Otto), Lemuel Wellman Wright, of Southwark, was granted patent No. 6525, which relates to a double-acting gas engine in which the charges of air and gas were delivered to the cylinder under pressure. It was, according to the specification, a vertical engine with water-jacketed cylinder, and the inventor shows the details of a water-cooled piston and piston-rod. Particular reference is made to mechanism for regulating the power output of the engine, the admission of the charge being controlled by a centrifugal governor. Ignition was by flame.

So much has been claimed for Gottlieb Daimler—who, without doubt, was a most fertile inventor and good craftsman—that it is appropriate to mention that at the date of Wright's patent Daimler was not yet born, his birthday being March 17th, 1834, the year in which Clapeyron contributed the paper which so greatly facilitated comprehension of the ideas of Sadi Carnot. Eugen Langen, Otto's collaborator, was born in 1833, so that the most conspicuous of the early German workers in the internal combustion engine field arrived in the world long after this engine had been "begründet" (founded), to use Güldner's expression.

When Otto was aged six, an ironfounder of Brighton, England, applied for a patent (No. 7615 of 1838), which was to prove of major importance in the further evolution of the internal combustion engine. The ironfounder was William Barnett, who not only described, for the first time, a really practical method of ignition by flame, but gave particular prominence to the compression of the explosive mixture prior to ignition. Barnett's specification and drawings were prepared with exceptional care and marked freedom from ambiguity, it being clear that he had given much thought to the process of scavenging. That he was born very far in advance of his time is well demonstrated by the fact that nearly half a century later Otto was still advocating the retention of the "residuum." It was in allusion to this patent of Barnett's that Mr. Justice Pearson, giving judgment in 1886 in the famous case of Otto *v.* Steel, remarked that "if Barnett does anything by his patent, it is to tell you to get rid of the residuum instead of retaining it." Barnett's gas engine was made and sold, and proved (in the words of the late Professor William Robinson) more successful than many that followed it.

There has been considerable reference, lately, to the alleged use by the Germans of hydrogen gas for submarine propulsion and to sundry German patents in this connection. No recent mention has been made—so far as the present writer is aware—of the hydrogen gas engine invented, but not patented, by the Reverend Mr. Cecil. As long ago as 1822 this little engine was seen at work in Mr. Cecil's rooms at Cambridge, and there is in existence a contemporary account of it. This states that "a mixture of one part of hydrogen and two and a-half parts of common air will expand, on being exploded, to three times its bulk, and then instantly collapse to a sixth of its original volume. A cylinder, with a piston and a light valve at its other end, is the chief apparatus. The hydrogen gas admitted into this and exploded by a jet of flame through a touch hole at the side will drive out the most of the common air from the cylinder by the end valve, which will clap to by the condensation afterwards, and force down the piston, by whose action the other valves, which admit the air and gas, are opened; when it again rises by the action of a counterweight, or of a fly-wheel, and the same process is again repeated." Much later, in 1840, William Henry Fox Talbot, of Laycock Abbey, Wiltshire, proposed (patent No. 8650/1840) to decompose water by means of a voltaic or galvanic battery, the oxygen and hydrogen gases resulting from electrolysis being led to the engine cylinder and exploded by means of a platina wire rendered incandescent by the electric current. Four months after the date of Fox Talbot's patent, James Johnston, of Willow Park, Renfrewshire, applied for patent No. 8841/1841, in which he describes a double-acting engine working on oxygen and hydrogen gases. He claimed the "working of an engine by the joint action of the explosive and condensive properties which certain proportions of oxygen and hydrogen gases possess when exploded together." He points out that all there is in the way of products of combustion is "a very small quantity of water." The present writer has not found any reference to a German hydrogen gas engine earlier than 1852, when Christian Reithmann, court watchmaker in Munich, is believed to have constructed an engine from which, using a mixture of air and hydrogen gas ignited by spark from a battery, power was obtained for driving the machinery in his workshop.

In 1844, John William Buckle Reynolds, of Lympston, Devonshire, received grant of a patent (No. 10,404), in which he describes a gas engine driven air compressor applied for automotive purposes. This was not the first proposal for a locomotive propelled by other than steam power, since the highly ingenious Yorkshire baronet already referred to (Cayley), had, in 1837, patented an application of his hot air engine for the propulsion of road vehicles. Reynolds, however, details what may be the first battery ignition arrangment embodying a practical make-and-break device. As a small coincidence it can be mentioned that just one day after the date of Reynolds' automobile patent, Carl Benz came into the world (November 26th, 1844).

In 1850, Floris Nollet, a Belgian, communicated through Edward Clarence Shepard patent No. 13,302, which describes an electromagnetic machine for igniting explosive mixtures. He also claimed magneto-electric current condensers in what appears to be the earliest reference to magneto-electric ignition. During the same year there was inaugurated by James Young, at Broxburn, near Edinburgh, the first process for the distillation of paraffin oil from bituminous coal and shale. This also was a development destined to be of great consequence for the internal combustion engine.

Four years later we come to one of the first strictly scientific inventors in the internal combustion engine field. He was an Italian, Eugène Barsanti, Professor of Physics and Mathematics in the Institut Ximeniano, Florence. Barsanti, in collaboration with another Italian, Felix Matteucci, devised an atmospheric gas engine with free piston. Their object in this design was to utilise, in the shortest time, as much as possible of the expansive force of the ignited charge. The first of Barsanti and Matteucci's British patents (No. 1072) was applied for in 1854, but "did not proceed to the Great Seal." In 1857 they applied for a further patent (No. 1655), in which there is a fuller description of their free piston gas engine, showing, among other things, ignition by electric spark (battery and De la Rive "multiplier"), a rotating circuit breaker driven from the engine being employed. Not much is known about the subsequent history of the Barsanti and Matteucci gas engine, though at least one example was built by the Société Anonyme John Cockerill, of Seraing. The possibility is that little more would have been heard of the free piston engine had not Eugen Langen, in collaboration with Nikolaus August Otto, developed the invention on good production lines, so that it became—and remained for a number of years—the standard atmospheric gas engine. Langen and Otto's patent was not applied for until 1866, but their "Flugkolbenmotor" (flying piston motor) is just the Italian free piston engine refined in its mechanical details and well constructed.

Meanwhile, in 1855, Dr. Alfred Drake, an American engineer, who had been working on the internal combustion engine since at least as early as 1840, applied through Alfred Vincent Newton for patent No. 562: "An improved Construction of Engine to be actuated by the Expansive Force of Explosive Mixtures." While this patent describes a variety of constructional details intended to relieve the engine of heat stresses and improve the lubrication of the cylinder, it is of historic importance as publishing, for the first time, the method of ignition by heated thimble, which was to become, some forty years later, of such high importance in the commercial development of the gas engine. It was in virtue of the thimble (or hot tube) ignition that a substantial increase in compression pressure was rendered practicable. Drake's specification also describes—without claiming it—a type of explosion starter, the engine being started by means of an "explosive mixture" which is led into the cylinder under pressure from a reservoir and fired by a heated thimble, the interior of which communicates with the cylinder.

It may be said that the first phase in the development of the internal combustion engine ended in 1859 with the completion, by the English engineer James Robson, of a horizontal gas engine of atmospheric type, double-acting, with crosshead and slot connecting-rod. Ignition was by electric spark on the make-and-break system, a side shaft operated from the engine crankshaft by bevel wheels being introduced for controlling the ignition and the exhaust slides. The construction of Robson's engine was commenced in 1858 and its features—which were never patented—can be recognised in the Lenoir engine, patented early in 1860. Robson's engine was of 3 H.P. and remained in use until about 1868, driving a circular saw at North Shields. Its end came when, during a severe frost, the cylinder jacket was fractured by freezing.

The engineer who takes the trouble to study the patent specifications referred to in this outline will find much to interest and instruct him. Above all, he will surely come to the conclusion that no more monstrous fallacy could be propagated than to claim, as did Güldner in the book already mentioned, that "Everything that has served to lay the foundation of the [internal combustion engine] industry and that has helped to make it vital and important, is either the product of German thought or was first made practical on German soil." Engineering knows neither frontiers nor political systems, and all nations have contributed to the development of engineering science. Never-

theless, it happens that in the early history of the internal combustion engine, as in the early history of the steam engine, German engineers had no part. This is a circumstance which it is well to remember at a time when long-sustained and intensive propaganda has been directed to inculcating the idea that the internal combustion engine is of German origin. Fortunate it is that—to quote an American saying—"Truth, run over by a locomotive, recovers; error, scratched on the forefinger, dies of lockjaw."

Flame Hardening

SINCE we last referred to the flame hardening process of Shorter Process Company, Ltd., of Savile Street, Sheffield, 4, continued development has occurred in the design of plant for operating the process. It will be recalled that the "Shorter" process consists of heating a limited area of the piece requiring localised hardening by means of gas jets, and immediately upon the correct temperature being reached quenching with water jets. In Fig. 1 there is illustrated the G.6 blade hardening machine, in which the gas and water jets are carried on a head that can travel along a track of any required length. This machine is suitable for hardening such things as machine tool beds, straight edges, and multi-parts fitted into jigs.

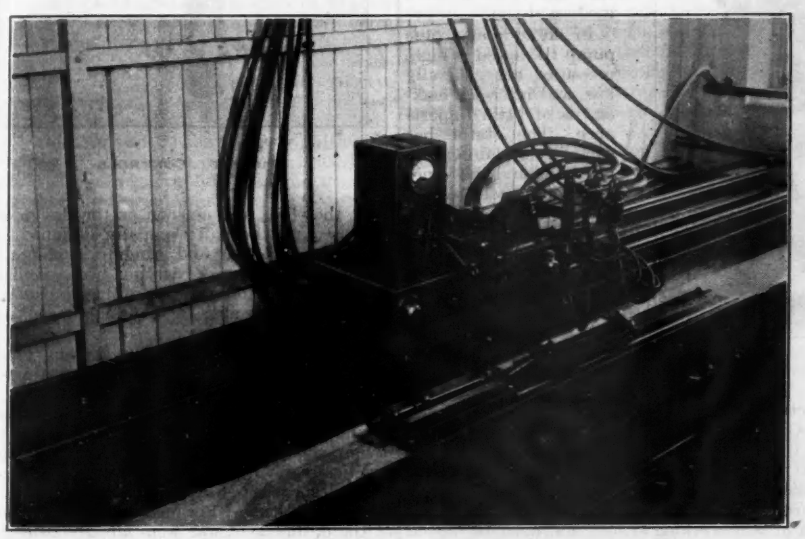


FIG. 1—BLADE HARDENING MACHINE

It is driven through a Ward-Leonard set, busbars being fitted at the back of the machine with contactors fitted to the machine head. The control panel is fitted with a speed indicator. This machine can also be fitted with automatic equipment for intermittent hardening. Multi-burners with multi-jets fitted to burner carriers are employed to cover any required width of face or number of faces to be treated simultaneously.

The Ward-Leonard set consists of a main driving motor connected to the public electricity supply. This motor drives a generator and also a small field exciter. All three machines are coupled together by means of flexible couplings and are mounted on a common base plate. This Ward-Leonard set generator supplies current to the geared variable-speed drive motor on the machine head. The exciter supplies current at a constant voltage to the field of the geared variable-speed motor. Current for the generator field is also supplied by the exciter, but in this case the current flowing through the generator field can be varied by means of the potentiometer provided on the machine head control panel. Thus the strength of the generator field can be varied at will between very wide limits, with the result that the output voltage of the generator can also be varied over a wide range. Since all other conditions remain unaltered, the speed of the geared drive motor is solely dependent upon the voltage of the current applied to its armature. The speed of the machine head is shown by a voltmeter calibrated in inches per minute, which is connected in parallel across the generator armature. It will be seen that the speed of the variable-speed geared motor is entirely independent of the load, any increase in load merely causing the motor to take more current from the generator.

The speed of the machine head can be varied between the limits of 1·4in. to 14in. per minute. The Ward-Leonard set is placed in a convenient position on the floor and a pilot switch controlling a contactor type starter is fitted in the control panel to enable the Ward-Leonard set to be shut down conveniently when not required. The control panel is also provided with a reversing switch to enable the machine head to be traversed in either direction.

The machine illustrated in Fig. 2 is perhaps of greater interest owing to its almost completely automatic operation. It is known as the N.2 machine, can be operated by women, and is suitable for hardening operations on a variety of small parts. The part to be hardened is placed in the machine and a central lever depressed by the left hand. By this action a cam is operated, which in turn operates a switch controlling by means of a solenoid the opening of the gas valve. The gas is ignited by a continuously burning pilot jet. Behind the operator in Fig. 2 there will be seen two clock faces. As soon as the gas is turned on the clock on the left, which is set to give exactly the necessary time to bring the surface of the part to the right temperature, begins to tick off the minutes or seconds. As soon as the time has expired the gas is automatically turned off and the water jets set going. The right-hand clock measures the time for quenching, turning off the water when it has expired. All these automatic operations are effected by means of electrical relays. As soon as the water ceases to flow the operator releases the lever and inserts a new part to undergo the process. Should any trouble arise part way through the operation, the operator merely releases the lever. Gas and water are immediately turned off and clocks re-set. The affected part can thus be rejected and operations be started anew on the next part.

For setting the heating and quenching times to suit any particular article, electrical press buttons, seen on the operator's right in Fig. 2, are used in conjunction with a stop watch. A button marked "Test Gas—On" being depressed, the burner lights up. The operating lever, being then depressed, brings the burner into the working position and the time to reach the critical temperatures is found against the stop watch. The "Test Gas—Off" button and "Test Water" button are then pressed to turn off the gas and bring the water jets into play. The time to quench is noted by stop watch. The clocks are then set to accord with the stop watch timings, a trial run is made and any necessary small adjustments effected and the machine is then ready to operate on a production basis.

The makers claim that they can now produce in one operation what is virtually a hardened and tempered job so that a steel which is capable of giving a hardness of, say, 800 diamond by direct quenching can be treated to a hardness between 500 and 600 without a second tempering operation. In the machine described special burners can be used, designed to localise the heating effect very exactly within the limits of the area to be treated. Another machine of similar type is fitted with a hopper and a trigger feed for small parts. It is entirely automatic in operation.

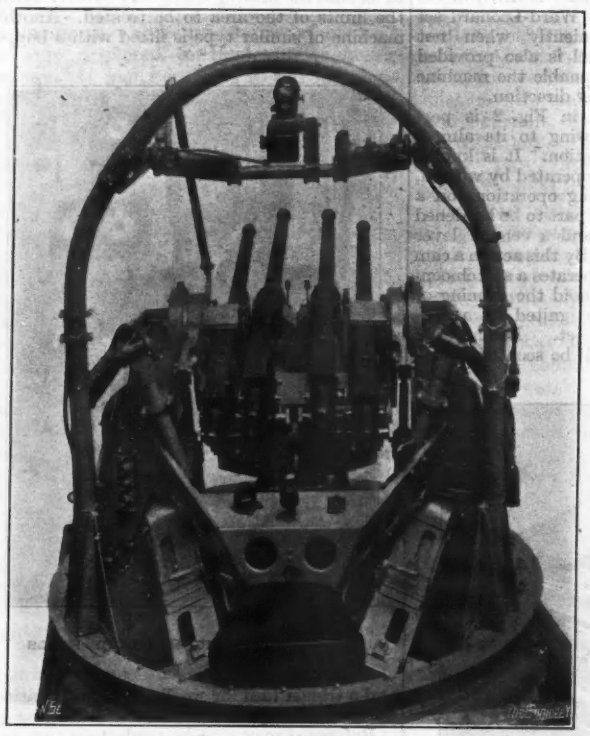
FIG. 2—HARDENING BEVELLED RINGS

Reference may also be made to a new type of machine now under construction, known as type T.1, for hardening of large circular paths. Hitherto this work has been done by carrying the heating and quenching equipment on a movable head radiating from the centre of the path to be treated and travelling upon the tread of the path. This method has now been superseded by mounting the rings to be hardened upon a turntable which is rotated in relation to a stationary burner head and control panel. This machine is capable of treating very large paths, such as large circular crane tracks of any required width. The speed of the headstock can be varied to suit rings between 9ft. 4in. and 1ft. diameter, the headstock taking a very large vertical thrust load.

PAPER ECONOMY COMMITTEE.—The Minister of Production has appointed a "Paper Economy Committee" to assist him in obtaining a reduction in the consumption of paper. The Committee will examine all cases of excessive use of paper and take the necessary steps to effect economy. Further economy in the use of paper is essential, and the Minister is satisfied that many economies can be obtained. He asks that all paper users will give the Committee all the help in their power in order that the necessary economies can be obtained with the least possible disturbance. The Committee consists of Mr. L. W. Farrow, chartered accountant (Chairman of the Committee), Mr. H. C. Tingay, managing director, George Newnes, Ltd., and Mr. B. C. Westall, managing director of Thomas de la Rue and Co., and its address is 3, Central Buildings, Westminster, S.W.1. Communications to the Committee will be welcomed, but in the interests of economy will not be acknowledged unless further information is required. The Committee is concerned with the economic use of paper and not with the collection of waste paper.

Parnall Gun Turret

ABOUT ten years ago, when the curve of progress towards greater aircraft speeds took a sharper upward trend, so that all problems relating to drag took on an ever-increasing importance, Captain A. Frazer-Nash and Captain E. G. Thompson realised that the time had arrived when the manual operation of turrets was beyond the capacity of a strong man and accuracy of aim quite unattainable. In the far-off days when the Scarff ring was introduced, the turret torque, with the gun abeam, was already enough to harass the gunner. Increased speeds soon took the torque up to 180–200 pounds-feet, with the immediate prospect of a still greater figure.



FOUR-GUN TURRET

It was therefore decided by Parnall Aircraft, Ltd., to prepare designs for a power-operated turret, in order that the requisite power and accuracy of fire could be obtained under modern flying conditions.

After consideration, it was decided to employ an hydraulic system of operation. This system lends itself to sensitive action and it was found possible to adopt a naturalistic form of control which is claimed to be almost instinctive. In fact, we are told by the makers that it is customary to demonstrate the turret action on the ground by putting a pencil on the end of the gun and writing with it! For the elevation of the guns, which is limited in extent, simple hydraulic rams are used, but for the traversing it is essential that the turret shall be unlimited as to rotation, and therefore a rotary motor is necessary.

Oil under pressure is supplied by an oil engine driven pump, generally of the gear type. Foaming and air locks are prevented by spring-loading the fluid reservoir employed in the circuit. The flow of oil to the turret is sensitively controlled by special rocking and swivelling hand grips, as illustrated in an accompanying engraving. It was only after considerable experiment that an action was obtained which would lead quickly to an instinctive use of the controls. The hand grips are duplicated, in case of any injury to the gunner during combat, but they both function in exactly the same way. Each is free to rotate in two planes, first about a vertical axis, secondly about an axis slightly inclined to the horizontal. These movements are transmitted by links to a valve-box which houses piston-type valves that control the oil flow to the oil motor for turret rotation and to the rams for elevating and depressing the guns. Both functions, of course, take place simultaneously, and one of the advantages of the instinctive action is the ease of holding steadily to any target path by suitably compounding the movement.

The hydraulic system gives great flexibility in control, from a very slow creep in either plane to quite a rapid traverse.

As first designed, the hydraulic motor was similar to a gear type oil pump. But leakage at low speeds was a weakness. After an investigation which covered multi-cylinder plunger and other types, the multi-vane oil motor was chosen, and one of the engravings shows a modern design.

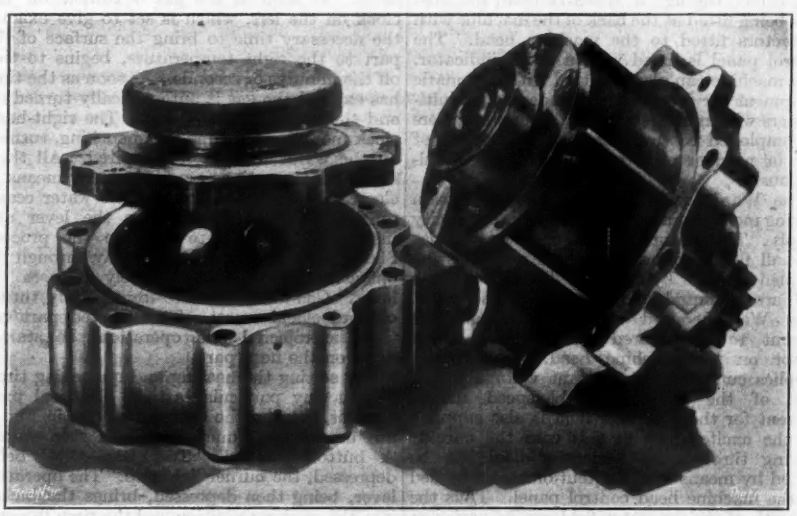
In an ordinary vane pump the speed is high, pressures are generally low, and inter-cell leakage is of little importance. The stator has generally a plain excentric bore, and the vanes are spring-loaded to take up the discrepancies of the changing "diameter" on which the vanes operate. But in this vane type oil motor pressures are fairly high and the speed at times may be very low. Considerable refinement in design and manufacture is therefore essential.

Owing to the degree of pressure employed, it is very desirable that the vanes should not have to slide during the pressure stroke. To satisfy this condition, the vane tips have to move on an arc concentric with the rotor spindle during the working stroke, and must be moved in and out only when subject to no pressure. At low speeds leakage must be reduced to very small proportions. As at such speeds there is no helpful centrifugal force to aid springs to force out the blades, spring-actuated blades were found liable to stick, and therefore unsatisfactory. In order to control the sliding of the vanes, therefore, the in-sliding vane is used to actuate the out-sliding vane by means of light tappet rods, which, staggered for the three pairs of vanes, pass diametrically through the rotor. This design requires that the motor chamber be so shaped that all chords passing through the centre of the rotor are of the same length. There is the concentric arc of the working stroke, and on the diametrically opposite side is a concentric arc of shorter radius, as demanded by the constant diameter consideration. These two arcs are joined by sides of special shape. Great accuracy is necessary in grinding this intermediate cam profile of the stator bore because, on the constant-chord basis, one half of the cam ramp must be complementary to the other.

The cam profile is obviously of basic importance, therefore, and as soon as the design was stabilised the Parnall Company designed and built its own boring and grinding machines for the work. The work-carrying head oscillates instead of the grinding head, so that the latter—with a wheel running at very high speed—can be rigidly mounted.

TURRET CONTROLS

Certain details, such as the shaping of the blade tips in order to obtain the best seal under line-contact conditions, needed a good deal of tedious experiment, and so did the hydraulic balancing of the blades, but eventually the design was so stabilised for production that practically no modifications have been necessary, despite the heavier duties put upon it from time to time. For instance, turret torques at the outbreak of war were already twice the 1932 figures; present-day figures cannot be quoted. This vane oil motor is claimed to give



VANE TYPE HYDRAULIC MOTOR

accurate and smooth action over a speed range from 0 to 1000 r.p.m.

Without modification, it is said, the present unit has given satisfaction, even at pressures as high as 1500 lb. per square inch, and it is only a question of straightforward engineering to utilise still greater pressures should conditions demand them.

An American Bi-centenary*

"In October, 1942, the Taylor-Wharton Iron and Steel Company, of High Bridge, N.J., will celebrate its two hundredth anniversary. So far as is known, it is the oldest industrial organisation in the United States. It is also believed to be the second oldest concern on the North American Continent, the oldest being the Hudson's Bay Company, which is now well on the way to completing its third century of existence. The Taylor-Wharton Iron and Steel Company has evolved from the Union Ironworks, which started operations in 1742 on the South Branch of the Raritan River, only a short distance away from the principal manufacturing plant and head offices of the present Taylor-Wharton enterprise. This location is approximately 54 miles west of New York City.

"The history of the iron working industry in this area begins with the arrival in the Colonies about 1686 of Daniel Coxe, a British doctor, who is said to have been the personal physician of Queen Anne of England. Within a few years after reaching these shores, Coxe had purchased between 500,000 and 600,000 acres in West New Jersey, his holdings comprising nearly one-fifth of the province. These lands were assigned to the West New Jersey Society, a group of some fifty men that was organised by Coxe. At the same time, on March 4th, 1691, Coxe invested the Society with the authority to govern this tract. In 1702, however, the prerogative of government was surrendered to Queen Anne.

"Despite this ownership of what later came to be known as 'the Society's great tract in Hunterdon County,' squatters settled on various isolated portions of it, and one of these is supposed to have set up the first ironworks along the South Branch of the Raritan. Just when this was done is not known, but some investigators have placed the date as early as 1700. It is on record, however, that by 1742 ore was being mined within the present limits of the borough of High Bridge, and that iron was being produced from it by the bloomery process, which was then probably known to only a few people in the Colonies.

"Two of the influential men of Philadelphia at that time were William Allen and Joseph Turner. Although only thirty-eight years old, Allen had been Mayor of the city, a member of the Common Council, and a member of the Assembly of the Province. He had studied law in London, and he and Turner had accumulated considerable money in a mercantile business that had been passed down by Allen's father. With the funds at their disposal, the two men began to buy up land and to interest themselves in the infant iron working industry. Their first investment was at Durham, along the Delaware River, below Easton, Pa., where the production of iron was responsible for the creation of a distinctive type of 'Durham' boat, which was used for many years to transport iron and produce down the river to Philadelphia. The property on the South Branch of the Raritan came to the notice of these two men and they apparently attempted, without success, to buy it. But, aware of other iron deposits in the area, or suspecting their existence, they leased 3000 acres adjoining the established works. Their leasehold took in 2 miles of the main stream and more than that length of a tributary, Spruce Run. The lease specified the right to search for iron, tin, lead, and copper, and to erect furnaces and forges for the production of metals. Allen and Turner in 1742 built a furnace on Spruce Run, nearly 2 miles from the old bloomery forge, and it was the business that was then started which persists to-day as the Taylor-Wharton Iron and Steel Company."

It is interesting to note that it was the Taylor-Wharton Company that introduced manganese steel in America some fifty years ago, very soon after its invention by Sir Robert Hadfield.

* Extract from *The Compressed Air Magazine* (New York), January, 1940.

Servicing Civil Aircraft

WE were recently invited by the British Overseas Airways Corporation to visit one of its many servicing stations and to see something of the way in which aircraft engaged in civil flying operations are cared for and overhauled in order to give the maximum efficiency under difficult wartime conditions. The war, it may be stated, has imposed on the Corporation's service engineering department a task without precedent in the history of civil aviation. The duty of the department is to maintain the Corporation's fleet of land aircraft and flying-boats in an airworthy condition. In times of peace this maintenance work would be carried out at one or two main bases, and the engineers engaged upon it would have at the most only two or three types of aircraft with which to deal. Under war conditions things, we found, are very different. The maintenance bases of the Corporation have been dispersed to many stations on the various world routes which it now serves. These routes extend from just south of the Arctic Circle to Durban in South Africa, and from the United States of America to Calcutta in India. They include, we are informed, no less than fifty-three stations for servicing land aircraft and forty-eight stations for the servicing of flying-boats, twenty-one of which are available for both types of aircraft.

Another important factor is that of the types of aircraft which may be employed for civil aviation. The very urgent need of fighter and bomber aircraft by the Royal Air Force has prevented the British Overseas Airways Corporation from acquiring the necessary replacement aircraft in order to maintain its services, and use has had to be made of such machines as were suitable for the services operated, including both British and American designs of machines. About 27 different types are now in use.

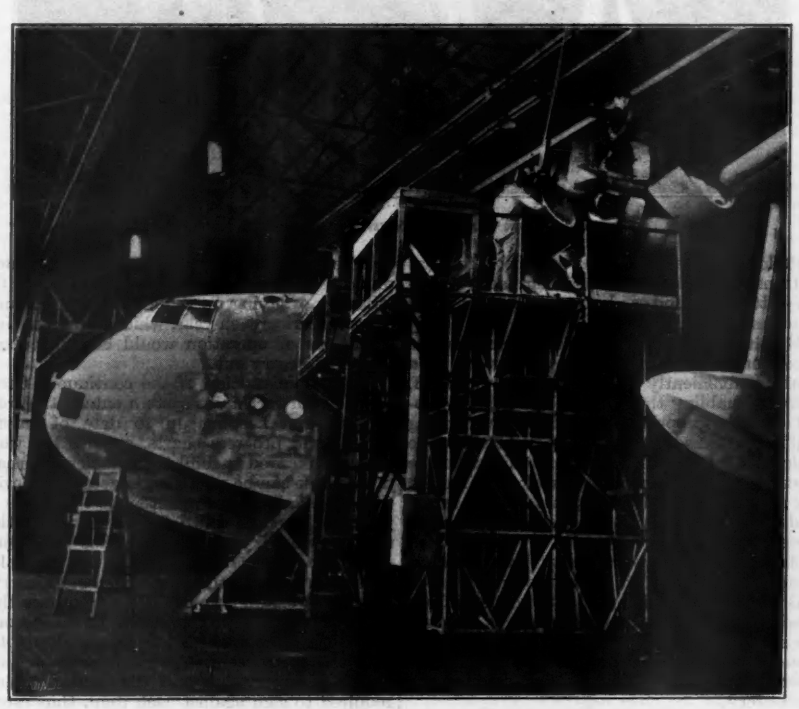
In order to solve the problem thus presented, it was necessary to undertake a comprehensive system of staff training and a world-wide dissemination of technical data. At the numerous bases we have already referred to some 50,000 spare parts have been distributed, many of which have had to be obtained from the manufacturers and very often delivered to the bases by air. Besides collecting spare parts it was necessary to design and construct tools and equipment, easily transportable, which can be used for each separate type of aircraft in service. The exigencies of wartime operations frequently require the transfer at short notice of aircraft from one route to another, which involves additional servicing operations in order to meet climatic conditions and make the aircraft serviceable in cold latitudes or in tropical climates, for which conditions appropriate modifications have to be made and allowed for in the maintenance programmes.

At the particular base we were invited to inspect marine flying-boats of British Airways were being overhauled and prepared for their journeys of many thousands of miles along the essential lines of communication of the United Nations' war effort, involving in some cases non-stop flights of over 1900 miles.

The regularity of the flying-boat services over these routes shows the sterling quality of British aircraft and equipment and reflects the greatest credit on the large and specialised staff of men and women in the service of the Corporation, whose duty it is to maintain the flying-boats in serviceable and airworthy condition.

Some idea of the routine involved in servicing a large flying-boat may be gained from the following description of a typical "turn-round" of a flying-boat at the conclusion of a service :—

As the crew comes ashore the captain is met at the head of the slipway by a responsible



SERVICING AN EMPIRE FLYING-BOAT

member of the Corporation's servicing staff, and inspectors go aboard to begin the preliminary examination of the aircraft whilst it is being beached. The captain's observations of the behaviour of the aircraft during flight are handed over, along with the technical log, in which all information relevant to the mechanical condition of the engines and navigation instruments, including equipment, is fully recorded. The performance of the aircraft and its engines is also recorded by means of readings taken at stated intervals during the flight on routine sheets, which include details of all adjustments made and repairs and maintenance carried out at distant stations. By this means the personnel at the servicing base is made aware of the mechanical history of the aircraft from the day it left the main base after its previous "turn-round." The technical log contains an inventory of all the petrol and lubricating oil which is uplifted *en route*. From these figures the consumption and the amount of lubricating oil used can be accurately computed.

Following the preliminary examination, the aircraft is beached and is drawn up by tractor or winch into its hangar, as illustrated. The servicing platforms shown in this engraving are brought up to the machine and the inspectors complete their preliminary examination. Simultaneously a thorough cleaning of the aircraft and its engines goes on. Attention may be called to the servicing platforms or rostrums, which are built up of lengths of steel scaffolding and are mounted on wheels for ease of transport. These, when dismantled, take up very little room and can be conveniently shipped to overseas stations.

PREPARING AN EMPIRE FLYING-BOAT FOR FLIGHT

By this time copies of maintenance routine sheets and inspectors' reports are put up on a board, conveniently accessible to all the staff, thereby enabling the supervisory staff to allocate to the appropriate members of the servicing staff any items of rectification which may be called for by the inspectors, in addition to the routine items of maintenance work which under the scheme of the Airworthyness Certificate, are undertaken regularly at the end of a prescribed period of flying.

Any accessories which may have reached their prescribed period of service are removed and are sent to the appropriate section of the base for overhaul. This procedure is adopted for such items as engines, airscrews, the radio installation, hydraulic and electrical navigation instruments, engine installation details, and upholstery.

After viewing the aircraft undergoing overhaul, we passed through the engine bay in which the engines are built up into a complete egg, ready for installing again in the engine nacelles. By this arrangement the changing of an engine unit is both an easy and a quick operation. In the unit shop we noted that all units removed from the engines and the aircraft are overhauled and prepared for refitting after undergoing satisfactory tests. Special testing equipment and rigs have been designed by the staff which are readily available to cover all the different tests needed. Many of these show the ready ingenuity of the Corporation's engineering staff. For replacements, a large stores is available, and items are recorded a few hours after their issue, so that stocks can be kept intact. The instrument shop contains equipment for testing all the scientific instruments used in the aircraft, which service is sometimes backed up by the makers' own workshops in the case of heavy repairs being needed. In the engineers' workshop and the carpenters' shop, equipment is available for the manufacture of all parts which may be called for during an overhaul. In the case of airscrews, provision is made for checking, stripping, and rebuilding airscrews, major overhauls being sent to centralised depôts. In a component bay, all removable parts of the aircraft, such as ailerons, elevators, rudders, fins, petrol and oil tanks, are dealt with.

For many years it has been the practice of British Airways to stagger the items of major overhaul work, so that each complete item can be attended to conveniently during the "turn-round" periods. Such a practice avoids the necessity of laying up the aircraft for a month or more during each year, which under wartime conditions of operation would be particularly difficult to carry out.

The administration of the continuous Certificate of Airworthiness system entails the compilation and keeping up to date of careful records and progress charts, so that the work which is required to fulfil the complete overhaul programme can be regulated in accordance with the time available for maintenance.

After the work called for on the inspection reports and the routine sheets has been completed to the satisfaction of the specialist supervisory staff, the inspection staff carries out a final examination in order to ensure that each item has been completed in full accordance with the standards laid down. We noted that the specialist staff which carries out the work, its supervisors and the inspectors, are required to sign against each item, thus establishing beyond all doubt the responsibility for the satisfactory completion of each job done.

At this particular stage of the overhaul the aircraft is withdrawn from the hangar, and the engines, controls, instruments, and ancillary equipment are given a thorough ground test. Throughout this test careful note is made of the performance of each item dealt with and any adjustments which may prove necessary are made and are recorded under the surveillance of the inspection staff.

The flying-boat is then launched, and a test flight carried out in order to ascertain whether the mechanical behaviour of the aircraft and her engines is satisfactory. Should any further adjustments be required, these are made under the same rigid supervision as is exercised in the hangar test and the ground test.

Following the overhaul, all signed copies of the routine sheets and the inspection reports are brought together in the office of the inspector in charge, where the "Aircraft Prepared for Service" form is duly completed. This document is used to advise the traffic and operations department of the tare weight of the aircraft, so that the fuel and oil requirements and the payload may be calculated. Often during the maintenance overhaul additions and alterations may be made to the structure and equipment of an aircraft, thereby altering the tare weight of the machine. It is most important to keep a careful check on the tare weight, so that, on the one hand, the maximum permissible weight which may be carried is not exceeded, while, on the other hand, valuable payload is not lost.

Finally, the serviced aircraft is in a position to again go into operation, and its airworthiness is certified by suitably qualified ground engineers, holding licences under the Secretary of State for Air.

Enough has been said to indicate the widespread activities of a typical base, having a combined administration and supervisory staff, including the inspecting staff of approximately 450 persons. Included are men engaged on engine and aircraft maintenance and overhaul, electrical work, instrument repair work, sheet metal work, unit repair, engineering and wood working, upholstery and cabin furnishings, and fabric work, besides launching and ground equipment maintenance.

The system of repairs and overhauls which we inspected reflects great credit on Mr. J. H. Robson, the service engineering director of British Overseas Airways Corporation, and his staff and men, who have all collaborated in bringing into being and maintaining in operation under difficult wartime conditions a scheme which now occupies the leading position among similar servicing arrangements carried out by air transport undertakings in different parts of the world.

ELECTRICALLY HEATED HOTBEDS.—The British Electrical and Allied Industries Research Association has published a report entitled "Simplified Electrically Heated Hotbeds," by C. A. Cameron Brown, B.Sc., A.M.I.E.E., and E. W. Golding, M.Sc., A.M.I.E.E. The report describes experiments carried out to determine whether a simple method of heating hotbeds electrically can be applied successfully to the intensive production of early salad crops in small frames, such as are used by amateurs. The method consists essentially in equipping a frame with a soil-heating cable or with a transformer-fed bare iron wire to give a loading of from 2 to 5 watts per square foot. Heating is controlled from a convenient point in the domestic premises from which supply is taken to give certain regular "doses" of heat in each 24-hour period. These doses vary from 40 to 45 watt-hours per square foot per day, depending on the district. The two most convenient modes of procedure appear to be either with a loading suitable for all-night running or with a lower loading suitable for continuous running. The method is designed for operation on the domestic two-part tariff and to take advantage of the low running charges available. The experiments have shown that the method is a practical and economical way of producing lettuces of first-class quality from mid-March onwards, with little attention and at a total cost, including overhead charges, well below the current retail prices in shops. While early lettuce is the main crop, other crops can be raised, either simultaneously, such as carrots, or in succession, thus adding to the value obtainable from the hotbed installation.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.r. Export quotations are f.o.b. steamer

India's Industrial War Effort

Few industries in India, big or small, are unaffected either directly or indirectly, by the war. If the war months of 1939–40 were months of exploration, 1940–41 was a year of planning and 1941–42 and beyond the gradual fulfilment of an expanding industrial war effort. In the first year of the war India executed war orders to the total of £62½ million. By the end of the second year they rose to nearly £123 million, and as at July 31st, this year, they totalled £273 million. War orders are now being placed at the rate of nearly £15 million a month. The production of rifles is six times the pre-war output, of machine guns eight times, of bayonets ten times, of gun ammunition twenty-four times, and of guns and gun carriages nine times. New types of shells, including 25-pounder, 3·7 anti-aircraft, and various types of armour-piercing anti-tank shells, are in regular production. T.N.T. and other high explosives are being manufactured at factories which have been expanded at a cost of £5¼ million. Two hundred and fifty men have been sent for training in Great Britain under the Bevin training scheme, of whom 122 have already returned, and every three months fifty will be sent for training. The American Technical Mission to India has sponsored several new plants and machine tools and has agreed to send special supervisory staff. The manufacture of alloy steels also is being undertaken, whilst the production of aluminium in India will be shortly on a scale which, it is expected, will ultimately enable her to meet her requirements. At the outbreak of war 600 trade workshops were available, but the Director-General of Munition Production has now 1500 engineering workshops, 840 for general engineering, 300 for small tools, and 345 plus 23 railway workshops for munition components. Over 30,000 men are employed in shipbuilding and ship repairing yards in India. The production of medical instruments for defence services in India was small in peace time and limited to a few simple instruments. Since 1939 this industry has kept pace with the demand of the defence services and 80,000 instruments have been sent to Russia. Indian steel makers have also undertaken the manufacture of alloy steels, and in one factory the production of ferro-silicon has been established and half India's requirements of the alloy will be met from this source. The capacity of a steel plate mill is to be extended by from 25 to 50 per cent. This mill supplies all the plate for shipbuilding repairs, as well as bullet-proof and heavy armour steel.

The Pig Iron Market

A somewhat stronger demand has developed in the pig iron market. This may be due to more than one reason, but principally to the fresh drive to increase the production of iron and steel required for armaments. A minor reason may be that the restricted buying policy which has been followed by a number of furnaces as a result of uncertainties of the concentration scheme for the foundry trade have so reduced consumers' stocks that they have been obliged to come into the market. The engineering and allied foundries are taking up large quantities, but their demands are chiefly for the higher-quality pig irons. Consumers' requirements are largely for low-phosphoric pig iron, hematite, and refined irons. There is a definite stringency in the case of hematite, and the position of the latter two descriptions is distinctly tight. So far as high-phosphoric pig iron is concerned, supplies are ample, and for some time there has been a fair demand for this class of pig iron, which is used increasingly for purposes for which, normally, it would be regarded as unsuitable. Users, however, are encouraged to use this class of iron where possible and are becoming accustomed to departures from practice necessitated by war conditions. The Control exercises a vigilant supervision over the distribution of all kinds of pig iron, and in the case of hematite no releases are made excepting when it is certain that no other description will serve and that the work for which it is required comes within the essential category. Refined and low-phosphoric pig irons are used largely as substitutes for hematite. Consumers do not have to exercise much pressure to obtain supplies of high-phosphoric pig iron and substantial stocks are said to exist in the Midlands. The difficulty of utilising the light castings industry on a big scale in the war effort and the light demand from the industries usually supplied by the light foundries has been reflected in a curtailment of the demands for high-phosphoric iron. Large quantities of basic pig iron are being produced and are passing into consumption, and in some districts the productive capacity has been almost entirely turned on to the manufacture of this description.

The Midlands and South Wales

The recent improvement in the demand for structural steel is making progress, and the belief that ruled at one time that this was merely a temporary movement has given place to expectations that the requirements of constructional engineering firms, who are better employed than for several months, are likely further to expand as a result of Government requirements for the building of aerodromes, camps, &c. The character of the demand has changed somewhat, recently, and while formerly the call was chiefly for medium and small sizes of joists and sections, the total volume of orders now comprise a much larger proportion of the heavier sizes. Practically all the works producing joists and sections have sufficient orders on their books to keep them busy beyond the end of the year. The demand for plates has not relaxed and all the plate mills are working to capacity. The sheet works are also actively engaged and have substantial order books. Considerable tonnages of black sheets are passing into consumption and there is an increasing call for painted sheets, which are now used as substitutes for galvanised. The pressure to obtain supplies of alloy and special steels is fully maintained and the works producing these descriptions of steel have enough orders in hand to keep them fully employed for a considerable period. An active business in most steel descriptions is passing in the Lancashire market. One of the chief features of current business is the insistent demand for plates, including light, medium, and heavy descriptions. The volume of business in special steels is also a noticeable feature of the market and the demand from the aircraft manufacturers and armaments and munitions makers is unceasing. An important business is also passing with collieries, who are taking big tonnages of props, arches, &c., although some works report that many of their customers have covered their requirements for some time. All descriptions of semi-finished steel are in demand, and the wire trade is taking large tonnages of wire bars. The steel works on the North-West Coast are fully employed, and it is believed that production in this district is increasing. The raw materials position is satisfactory and the works have a sufficient tonnage of orders in hand to keep them busy for the remainder of the year.

The North-East Coast and Yorkshire

Pressure of demand on the iron and steel works on the North-East Coast is gradually increasing. All available plant is in full operation, and as there is no additional labour to draw upon the only way left to increase production is by greater efficiency, and throughout the district managements are turning their attention to this aspect of the problem. It was expected that the last quarter of the year would be a period of intense operation, and to all appearances this phase has commenced and the requirements from the consuming industries employed upon essential work seem to be growing from day to day. It is greatly to the credit of the steel industry and to the distribution methods of the Iron and Steel Control that, except in isolated cases, delivery dates are not being extended. The heavy demand for plates, particularly for ship plates and boiler plates, has been fully maintained, and in this section a tendency is noticeable for delivery dates upon new business to become rather extended. Great efforts, however, are being made to keep this movement within bounds, and, as a general rule, notwithstanding that most works are booked up beyond the end of the year, consumers are able to arrange for delivery within a reasonable time. The demand for structural steel is moderately active and there is a noticeable improvement in the call for heavy joists. Considerable quantities of steel are also passing to the collieries in the shape of roofing bars, arches, &c. Although the production of iron and steel in Yorkshire has been maintained at a high level practically since the war began, new output records have been reached. The pressure from consumers for basic steel is insistent. The plate makers are kept exceedingly busy, whilst the demand for special and alloy steel appears to be increasing more quickly than the production, but renewed efforts are being made to increase the output of these descriptions. A huge business is passing in semi-finished steel, and although the British works are operating at capacity, the deliveries have to be supplemented by withdrawals from stocks of imported material. These withdrawals, however, are being carefully watched by the Control, and it is not likely that this movement will be permitted to go beyond what is absolutely necessary. Both the steel works and the re-rolling works are benefiting by the revival in the demands for structural steel, and the majority of the works are engaged to the limit on orders for sections, which will keep them employed for the remainder of the year. The sheet mills are actively engaged, principally on black sheets, and are carrying good order books. The demand for painted sheets has broadened lately and the works are turning out large quantities.

Scotland and the North

The Scottish iron and steel industry is fully employed and has enough work in hand to keep it busy for a long time. Attention has been drawn recently to the fact that the trade is almost wholly employed in doing work for Government Departments, and that its whole production is for the satisfaction of essential requirements. The general position of the steel trades does not appear to have changed. For some time past the principal demand has been for plates, the production of which has been maintained at a high level. Practically all descriptions of plates are included in the demand, but the largest quantities probably are passing to the shipyards and the ship repairing yards. In other departments also there are indications that tight conditions are developing. For months past the position with regard to alloy and special steel has been stringent, but by careful distribution the Control has enabled supplies to be maintained to firms employed upon essential work. During recent weeks there have been particularly heavy deliveries of armour plate, whilst the demand for joists and sections, both heavy and light, is keeping the makers busy. Active conditions rule at the works of the constructional engineers, who have lately been big consumers of plates and sheets. The sheet works, which are assured of busy conditions for some months, are principally engaged in producing black sheets, although they have also a considerable tonnage of orders in hand for special qualities. In the Lancashire market active conditions rule in most departments of the iron and steel trades. The volume of business in structural steel, which recently showed some improvement, has not developed further, but most of the manufacturers are well placed as regards orders. There is an important business passing in steel bars of all diameters, which is keeping the re-rolling industry as well as the steel works fully employed. The demand for reinforced concrete rods has shown a tendency to decline, but this has been more than made up by the increased demand for small steel bars. The engineering works seem to be particularly heavy consumers of the former description. The demand from the collieries, which has been pressing for a long time, shows no signs of declining and large tonnages of arches, roofing bars, etc., are passing into consumption. The steel works on the North-West Coast are busily engaged on full programmes. Production is at a high level and is being pressed to the utmost.

Iron and Steel Scrap

The iron and steel scrap markets have been rather more active of late, but this is not an unusual movement at the beginning of the quarter, when a number of consumers took steps to cover their requirements for a little time ahead. For another reason the consumers have received their allocations for the ensuing three months and are busy covering them. There is an urgent demand for good heavy mild steel scrap cut to furnace sizes, at 69s. 3d. and 73s. 6d., and to cupola sizes at 82s.; but supplies are not sufficient to meet consumers' requirements and show no signs of increasing. There is also considerable business passing in bundled steel scrap and hydraulically compressed steel shearings, quoted at 64s. and 67s. 3d. and 69s. 3d. and 72s. 6d., respectively. Consumers are searching for parcels and are taking up all they can find. There is a poor request for mild steel turnings and the inquiry seems to be declining. This is probably because most of the steel works have already covered their needs for some time to come. Hydraulically compressed destructor scrap is also in less demand than recently. Only a quiet trade is passing in mild steel turnings and most users are reluctant to increase their commitments. There is an active business, however, in mixed wrought iron steel for basic furnaces. Good heavy scrap at 67s. 3d. and 70s. 6d. is quickly taken up, while light material at 49s. 6d. and 53s. 3d. is passing slowly into consumption. Heavy cast iron is quoted at 70s. 3d. to 80s., and lately there has been a better demand, although there is room for improvement. The market for light cast iron scrap at 71s. 6d. and 74s. 9d. is restricted, but it shows some improvement when compared with recent weeks. Consumers seem reluctant to take up any large quantity of railing scrap and light cast iron and cast iron borings. The demand for machinery cast iron scrap is in excess of supplies and consumers take up any quantities offered.

Notes and Memoranda

Rail and Road

NEW S.R. LOCOMOTIVE.—The latest addition to the Southern Railway's "Merchant Navy" class locomotives is the "Orient Line," named on Monday, November 2nd, by Mr. I. C. Geddes.

FOREIGN-OWNED RAILWAYS IN MEXICO.—It is reported in Mexico City that the Mexican Railwaymen's Union has asked the Government to purchase the British-owned Mexican Railway and the Southern Pacific Railroad of Mexico (a subsidiary of the Southern Pacific of the United States). An earlier Press report that such a purchase was contemplated was contradicted by the Mexican Director-General of Information.

THE ALASKA RAILWAY.—The great highway from Edmonton in Canada to Fairbanks in Alaska is carrying traffic both ways, but a decision by the United States Government regarding the building of a railway to Alaska hangs fire. The Premier of British Columbia has stated in Vancouver, following his return from Edmonton, where he took part in a conference discussing the project, that something may be decided before Christmas.

GERMANY OBTAINS DUTCH ROLLING STOCK.—The military authorities in Holland have transferred all the diesel units of the Netherlands Railways to Germany. The booty consists of forty articulated three-car units, five of which had a 350 H.P. motor unit and the others 400 H.P., with second and third-class passenger accommodation and a luggage compartment. These trains were taken out of service after the German invasion, when diesel oil supplies ceased.

ANOTHER PAN-AMERICAN HIGHWAY.—Six Central American Republics are joining with the United States to construct an emergency road to by-pass the submarine menace and provide an overland route from the United States to the Panama Canal. Guatemala, Salvador, Honduras, Nicaragua, Costa Rica, Panama, and the United States have agreed to co-operate in the construction plans, which call for about 625 miles of pioneer road to fill the gaps in the Inter-American Highway, the completed segments of which now aggregate about 1000 miles.

TRAMWAY RAILS FOR SCRAP.—So that all old and disused tramway rails shall be treated as remelting scrap, the Minister of Supply has issued the Control of Iron and Steel (No. 25) (Scrap) Order, 1942, which came into force on November 3rd, 1942. The Order provides that no person may treat, use, or consume tramway rails, except as part of a railway or tramway track or as scrap for remelting, unless licensed by the Minister of Supply. Copies of the Order may be obtained from H.M. Stationery Office, York House, Kingsway, W.C.2, or through any bookseller, price 1d.

Air and Water

AIRCRAFT SALVAGE IN THE PACIFIC ZONE.—An extensive aeroplane repair depôt and base, equipped to salvage Allied aircraft damaged in action, has been constructed in record time somewhere in Australia. Constructed in four months, at a cost of nearly £2,000,000, the enterprise covers 30 square miles and has 450 buildings, including hangars and workshops. Salvage of damaged aircraft has already been started.

CANADIAN PETROL PLANT.—The construction of an aviation petrol plant at a cost of 1,000,000 dollars on Imperial Oil property in East Calgary, Alberta, is under way. The Allied War Supply Corporation, backed by the British, United States, and Canadian Governments, is undertaking the project. The plant will produce alkylate from high-fractional gases. This fluid, when blended with ordinary petrol, yields a high-octane product essential in the operation of powerful modern war aircraft.

DUPLICATION OF AIRGRAPHS.—The Postmaster-General announces that duplicates of the airgraph mails which were on board the flying-boat "Clare" when it was lost have now been received from the several countries of origin and the airgraph messages have been delivered to the addressees. It has been decided to adopt a similar course as a normal arrangement in the case of airgraph mails lost in transit; if duplication is found to be impracticable on any occasion owing to exceptional circumstances, an announcement to that effect will be made at the earliest appropriate moment. The "Clare" was carrying airgraph mails from India, East Africa, South Africa, and from civilians in the Middle East. She was lost at the end of September, and promptly the airgraph section of the General Post Office cabled to the various countries to send over by air copies of the original films of the airgraph letters. These arrived in this country on October 15th. Within three days the enlargements had been made and delivered.

Miscellanea

CENTRALISING SALVAGE OPERATIONS.—One of the biggest railway salvage dumps in the United States is at Lackawanna, Scranton, Pa. Built in 1926, it handles 25,000 tons of scrap yearly. About one-third of this tonnage is reconditioned for further railway service, while the rest now goes into the nation's scrap pile.

GERMAN BOTTLE NECKS.—"Some people seem to think," says *Iron Age*, "that Germany's industrial war effort runs with clocklike precision and that her industries are walking the production tightrope with the skill of a somnambulist perambulating a tenth-storey cornice with his eyes shut. You can bet your bottom dollar that there is a lack of balance constantly occurring in Germany, too, even though her economic administrators and industrialists have been practising on the war production tightrope for ten long years."

PHOTOGRAPHY IN INDUSTRY AND SCIENCE.—The Association of Scientific Workers is promoting an exhibition, "Photography in Industry and Science," to be held during November in the rooms of the Royal Photographic Society at 16, Prince's Gate, S.W.7. The exhibition will be opened by Sir Robert Watson Watt, F.R.S., under the chairmanship of Mr. D. McMaster (President, R.P.S.), on October 31st, at 3 p.m. The field covered by the exhibits will be wide and have particular reference to the war effort, including work on machine movement analysis, radiography of castings, &c., mapping and surveying, crystallography, astronomy, nuclear physics, template making, &c. Exhibitors will include the Ministry of Information, technical branches of the three Services, individual technicians and the large photographic firms.

Personal and Business

MR. W. A. SHEPHERD has become a director of the Trent Navigation Company, Nottingham.

J. H. FENNER AND CO., Ltd., Heckmondwike, Yorks, have opened a new branch office at 16, Westfield Street, Cardiff, under the charge of Mr. Neville D. Jones.

THE L.N.E. RAILWAY announces that Mr. J. B. Dawson, district engineer, Sheffield, has been appointed parliamentary and surveying assistant to the engineer, Southern Area.

MR. H. PEARSON FOSTER, M.I. Struct. E., M. Inst. M. & Cy. E., is resigning on superannuation on January 1st, 1943, from his position as constructional engineer in Leeds City Transport Department after forty years' service with the Leeds Corporation.

THE METROPOLITAN-VICKERS ELECTRICAL EXPORT COMPANY, Ltd., has received an order for ten four-axle double-bogie electric locomotives of 1200 H.P., supplied with D.C. at 3000 volts, for main line service in Natal. These locomotives are similar in all respects to those previously supplied to the South African Railways, and bring the total number supplied by Metropolitan-Vickers to 174. The order is for delivery in 1943, beginning in August or September. The mechanical parts will be made by Beyer, Peacock and Co., Ltd., acting as sub-contractors.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Special Libraries and Information Bureaux

Saturday and Sunday, Nov. 7th and 8th.—Royal Society's Rooms, Burlington House, Piccadilly, W.1. Annual conference.

Bradford Engineering Society

Monday, Nov. 9th.—Technical College, Bradford. "Steam Traps and Trapping," F. Blezzard. 6.45 p.m.

Illuminating Engineering Society

Tuesday, Nov. 10th.—E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, W.C.2. "The Lighting of Docks," T. Nisbet. 5 p.m.

Institute of Economic Engineering

Sunday, Nov. 8th.—Waldorf Hotel, Aldwych, W.C.2. "The Function of Time Study in Industry," A. Griffiths. 2.30 p.m.

Institute of Fuel

Thursday, Nov. 12th.—Connaught Rooms, Great Queen Street, Kingsway, W.C.2. "The Provision of Smokeless Fuel for Post-war Reconstruction," G. E. Foxwell. 2.30 p.m.

Saturday, Nov. 14th.—MIDLAND BRANCH: Grand Hotel, Birmingham. Discussion, "The Battle of Fuel in Industry." 2.30 p.m.

Institute of Marine Engineers

Tuesday, Nov. 10th.—85–88, The Minories, E.C.3. "Cargo Ships and Propelling Machinery Adapted to War Conditions," W. S. Burn. 5.30 p.m.

Institute of Welding

Tuesday, Nov. 10th.—SCOTTISH BRANCH: Ca'doro Restaurant, 120, Union Street, Glasgow. "Welding Procedure in the Americas," J. L. Adam. 5.45 p.m.

Institution of Automobile Engineers

Monday, Nov. 9th.—DERBY GRADUATES: School of Arts, Derby. "Power Plants in Prospect: A Twenty Years' Prophecy," F. H. Bothamley. 7 p.m.

Tuesday, Nov. 10th.—LUTON GRADUATES: Technical College, Luton. "A Brief Review of the Diesel Engine," G. Heslip. 7.30 p.m.

Sunday, Nov. 15th.—LONDON GRADUATES: 12, Hobart Place, S.W.1. "Cross Rotary-valve Engine Development," J. Jack. 2.30 p.m.

Institution of Chemical Engineers

Tuesday, Nov. 10th.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "A New Method of Graphical Representation and its Application to Vapour-liquid Equilibria," A. L. Bloomfield. 2.30 p.m.

Institution of Civil Engineers

Tuesday, Nov. 10th.—Great George Street, Westminster, S.W.1. Discussion, "Civil Engineers and the Building Industry." 2.30 p.m.

Tuesday, Nov. 17th.—RAILWAY ENGINEERING DIVISION: Great George Street, Westminster, S.W.1. "Railway Signalling and Communications," A. E. Tattersall. 5.30 p.m.

Institution of Electrical Engineers

Monday, Nov. 9th.—N.E. CENTRE: Neville Hall, Westgate Road, Newcastle-upon-Tyne. "The Soot Blower," R. J. Glinn. 6.15 p.m.

Tuesday, Nov. 10th.—SCOTTISH CENTRE: Societies' Room, Royal Technical College, Glasgow. "Open-hearth *v.* Electric Furnaces in Steel Works," H. A. Sieveking and J. A. Davies. 6.15 p.m.

Wednesday, Nov. 11th.—TRANSMISSION SECTION: Savoy Place, Victoria Embankment, W.C.2. "The Technical Implications of the Scott Report as Applied to Electricity Supply," J. A. Sumner. 5.30 p.m.

Thursday, Nov. 12th.—INSTALLATIONS SECTION: Savoy Place, Victoria Embankment, W.C.2. "Voltage Surges Caused by Contactor Coils," J. R. Taylor and C. E. Randall. 5.30 p.m.

Institution of Engineers-in-Charge

Saturday, Nov. 14th.—Magnet House, Kingsway, W.C.2. "Infra-Red Lamp Heating," F. E. Rowland. 2 p.m.

Institution of Mechanical Engineers

To-day, Nov. 6th.—Storey's Gate, Westminster, S.W.1. Thomas Hawksley Lecture. "Recent Developments in Refrigeration." Lord Dudley G. Gordon. 5.30 p.m.

Saturday, Nov. 7th.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester. "Welding," R. W. Bailey and J. A. Dorratt. 2.30 p.m.—WESTERN BRANCH: Merchant Venturers' Technical College, Unity Street, Bristol. "Recent Developments in Refrigeration," Lord Dudley G. Gordon. 2.30 p.m.

Saturday, Nov. 14th.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester. "Recent Developments in Refrigeration," Lord Dudley G. Gordon. 2.30 p.m.

Monday, Nov. 16th.—MIDLAND GRADUATES: Watt Memorial Institute, Great Charles Street, Birmingham. "High Test Cast Iron as a Substitute for Steel," E. Hunter. 7 p.m.

Institution of Production Engineers

To-day, Nov. 6th.—COVENTRY SECTION: Stewards' Room, Central Hall, Coventry. "Coventry Dieheads and Dies," H. A. Drane; and "Grinding and Lapping of Tungsten Carbide Tools," F. H. Bates. 6.45 p.m.

Saturday, Nov. 14th.—YORKS SECTION: Great Northern Hotel, Leeds. Discussion, "The Young Production Engineer: His Training and His Prospects." 2.30 p.m.

Junior Institution of Engineers

Friday, Nov. 13th.—39, Victoria Street, S.W.1. Annual general meeting. 6 p.m.

Newcomen Society

Wednesday, Nov. 11th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. Annual general meeting. "Suffolk Windmills—Part II, Tower Mills," R. Wailes. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, Nov. 13th.—Mining Institute, Newcastle-upon-Tyne. "The Water-tight Subdivision of Merchant Ships, with Special Reference to the Use of a Water-tight Deck," W. Muckle. 6 p.m.